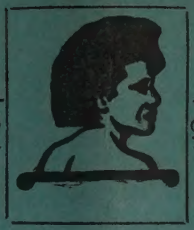
VOL. 26 NO. 2 JUNE, 1955



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Notes for Librarians and Research Institutes

AGRICULTURAL JOURNAL, 1928-54

So many requests are received for parts of the " Agricultural Journal " which were never published or which are now out of print, that the following list of all issues published is given for reference. Those volumes and numbers which are not now available are marked with an asterisk. It will be noted that copies of all parts of eight volumes and parts of six other volumes are unobtainable. Should any reader have unwanted copies of these publications, the Librarian would be grateful to receive them.

Vol.			
1.	3	numbers,	1928.
2.	4	,,	1929.
3.	3	,,	1930.*
4.	4	,,	1931.
5.	2	,,	1932.*
6.	2	,,	1933.
7.	1	,,	1934.
8.	4	,,	1935-7.*
9.	4	,,	1938.*
10.	4	,,	1939.*
11.	4	,,	1940.*
12.	4	,,	1941* (Nos. 1 and 2).
13.	4	,,	1942* (Nos. 1 and 2).
14.	4	numbers,	1943* (No. 3).
15.	4	,,	1944* (No. 2).
16.	4	,,	1945.*
17.	4	,,	1946.*
18.	4	,,	1947* (No. 1 and 4).
19.	4	,,	1948.*
20.	4	,,	1949.
21	3	,,	1950* (Nos. 1 and 2).
22.	1	,,	1951.*
23.	3	,,	1952.
24.	4	,,	1953.
25.	4	,,	1954.

AGRICULTURAL CIRCULAR, 1920-25

NUMBERS and year of issue of the " Agricultural Circular " :—

Vol. 1, 1920, 12 numbers.
2, 1921, 5 ,,
3, 1922, 4 ,,
4, 1923, 1 number.
5, 1924-5, 2 numbers.

As number 4 of Vol. 3 was printed as " Volume 4 " and number 1 of Vol. 4 as " Volume 5 " it would appear from an inspection of a complete set that Volume 4 comprised only a number 4 and that there were two issues of Volume numbered as 5, No. 1.

ANNUAL BULLETINS, 1931-38

COPIES of Annual Bulletins of Divisional Reports for the year 1933 and 1934 ONLY are available.

AGRICULTURAL BULLETINS, 1911-54

A FEW copies of the following bulletins are available at the prices shown. Other Bulletins previously listed are out of print.

No. 1. Sisal Hemp in Fiji, by C. H. Knowles, 1911. Price 2s.
7. A Mission to Java for a Coleopterous Pest of Bananas, by Jepson, 1914. Price 2s. 6d.
23. Insect Pests of Fiji, by R. J. A. W. Lever, 1946. Price 1s.
34. The Botanical Gardens, Suva, by J. W. Parham, 1948. Price 1s. 6d.
25. Copra Drying and Copra Driers, by W. J. Blackie, 1950. Price 1s. 6d.
26. Mechanisation of Rice Padi Cultivation by R. R. Mason. Price 2s. 6d.

AGRICULTURAL REPORTS

RECENT reports on Agricultural subjects are available as follows :—

Rhinoceros Beetle Eradication Board. Report C.P. No. 39, 1954. Price 1s. 6d.
Coconut Rehabilitation Committee 1954. Report C.P. No. 40, 1954. Price 1s.
Department of Agriculture Annual Report, 1953. C.P. No. 37, 1954. Price 5s. 6d.
Department of Agriculture Annual Report for 1954. C.P. No. 9, 1955. Price 2s.
Report by Sir Geoffrey Clay on his Visit to Fiji in 1954. C.P. No. 31, 1955. Price 1s. 6d.

OTHER PUBLICATIONS

A FEW copies of the following important book are available :—

The Coconut Moth in Fiji, by J. D. Tothill, H. C. Taylor and R. W. Paine. Imperial Bureau of Entomology, 1930. Price £1.

FORTHCOMING PUBLICATIONS

THE following publications are in the press and will be available shortly ; price not yet determined.

Bulletin No. 28 ... ... Soil Erosion and Conservation in Fiji, by C. E. Whitehead (approximately 48 pp. and 60 illustrations).
Bulletin No. 29 ... ... The Grasses of Fiji by J. W. Parham (approximately 96 pp and 73 illustrations).
Book ... ... The Fishes of Fiji by H. W. Fowler (approximately 600 pages and 200 illustrations).

Agricultural Journal

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CONTENTS

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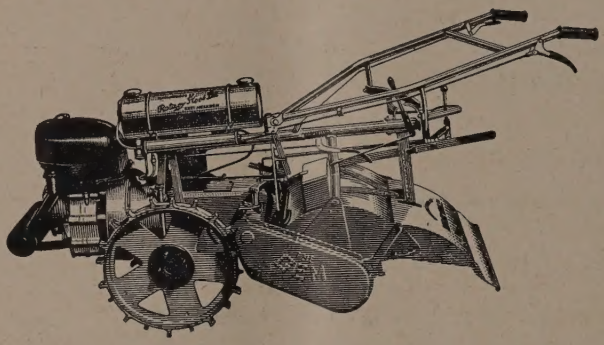

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EDITORIAL . . .

LIVESTOCK INDUSTRY

With a fifth to a quarter of the total land area of the Colony suited only to some form of livestock rearing, and with an annual import into the Colony of nearly half a million pounds value of livestock products, there need be no apology for an issue of this Journal in which pasture improvement takes pride of place. There is a hungry market for all the beef and milk likely to be produced in the Colony for many years to come, yet the expansion of production is disappointingly slow. The consumption of local beef, as measured by the number of killings in registered slaughterhouses, has increased since the system of butchers' quotas was relaxed two years ago ; but fears have been expressed from time to time that this increase has been at the expense of working bullocks sold off by farmers and replaced with tractors rather than to a real expansion of beef production. The production of whole milk for sale has undoubtedly increased without any corresponding reduction in the manufacture of butter ; yet the quantity of preserved milk imported continues to grow.

Whatever the factors may be that are responsible for the discouragement of an expanded livestock industry (the ones commonly suggested are :—difficulties associated with land tenure, the high cost of fencing, an undiscriminating consuming public, and the cost and scarcity of concentrate feed)—it is certain that pasture improvement by better management must form an integral part of any plan for the proper utilisation of the Colony's grasslands. This was recognised in the development plan, and the programme of investigations provided under this plan is now producing a flow of useful information which should prove of practical value to farmers. —C.H.

AGRICULTURAL ADVISER'S REPORT, 1954*

The recommendations of the Economic Review Committee 1953 *so far as they relate to agriculture are endorsed, and the following proposals made* :—

(*a*) An ecological survey of the interior of Viti Levu and Vanua Levu.

(*b*) Dr. Eden, Director of East African Tea Research Institute should visit Fiji to report on prospects of tea production.

(*d*) Diversification of production be attempted and small economic missions from Australia, New Zealand and Canada should be invited to visit Fiji.

(*e*) Increased experimental work in agronomy of sugar cane. Mr. P. E. Turner, lately Sugar Agronomist in the West Indies should visit Fiji to review work and to make proposals for a five year scheme to be financed by Colonial Development and Welfare funds.

(*f*) That trials with cacao under coconuts in Taveuni be encouraged.

(*g*) That the Native Land Trust Board increase staff of Assistant Land Agents and establish husbandry farms as demonstrations similar to District farm at Dobuilevu. Also that Department of Agriculture should establish a small Agricultural Experimental Station in Lautoka-Nadi Area.

(*h*) That Fijian communal labour obligations should be limited to 30 days per annum for social services and for productive work and that no special criteria other than ability to pay the commutation fee at the rate of 5s. per day should be demanded of individual Fijians wishing to devote their energies to private independent farming enterprises.

(*i*) That the Fijian Banana Venture should be converted into a Fijian Agricultural Development Scheme and incorporated by Ordinance.

(*j*) That the Fijian Affairs Board create posts of Tikina Agricultural Assistants.

(*k*) That the Director of Agriculture and Conservator of Forests should be recognized as advisers to Fijian Affairs Board ; Agricultural Officers should be members of Provincial Councils ; and Agricultural Field Assistants should be members and attend all meetings of Tikina Councils.

(*l*) That Department of Agriculture with Native Land Trust Board carry out trials in community pastures in Viti Levu.

(*m*) That outside assistance should be sought in investigations into Rhinoceros Beetle and Stick Insect and in spraying techniques.

* Sir Geoffrey Clay, K.C.M.G. O.B.E., Agricultural Adviser to the Secretary of State visited Fiji for five weeks early in 1954. His report is now published as Council Paper No. 31, 1955, and copies are available at 1s. 6d. each.—Ed.).

LAND USE AND DEVELOPMENT . . .

NOTES ON TYPING FIJI GRASSLANDS FROM AERIAL PHOTOGRAPHS

BY G. W. COTTLE*

Increasing use of aerial photographs for the locating and typing of vegetational units has been made by the Forestry Department in recent years. Although the principal work of the Department takes place in forested areas it is also concerned with the formation of tree crops on treeless areas with infertile soils or steep slopes, and with the protection of water catchment areas. During investigations of areas for protection and planting considerable data and experience in the typing of the grasslands of Fiji has been acquired which may be of value to agriculturalists.

The first study was carried out on the Lautoka Water Catchment area. The object was to find whether any types of grassland could be discerned using aerial photographs only, and if so, to investigate soil and general fertility relationships to the vegetation types, as this would have considerable influence on the choice of tree species to be planted and the technique to be used.

The photographs used for this investigation were taken by Messrs. Hunting Aerosurveys Ltd. in 1951, and the scale of photography for ground at about sea level is 1/16,000 or approximately 20 chains to 1 inch.

The main factors used in separating grassland types are colour (tone, perhaps would be a better word as the photographs are monochromatic) ; texture, that is the rough, smooth or characteristic kind of surface an area presents when viewed through the stereoscope ; and form, which is the shape and size of the individual components of the vegetation which the stereoscopic viewing reveals. Very often as in the case of Casuarina species or Palm Trees it is the characteristic shadow thrown which is the most important identification feature. Good use can often be made of an inverted stereoscopic image. This may be obtained when photographs are viewed in such a way that the shadows fall away from the obesrver ; this has the effect of making mounds and rises appear as hollows and vice versa.

In using these identification characteristics there are certain pitfalls which should be avoided ; some of the most important ones are as follows. For instance, if photography has been preceded by burning the land, the fired area will have an appearance which will vary according to the time lapse between burning and photography. Also when using colour for identification the amount of development which the prints have received must be correctly assessed. This can be done by comparing several common points on adjacent photographs. Other difficulties are discussed in the description of vegetation types.

The Lautoka Water Catchment Area.— The Lautoka Water Catchment area has an approximate area of 5 square miles, and occupies the upper catchment area of the Saru Creek. The area lies about 5 miles inland on the north-west side of Viti Levu, and the elevation varies from an estimated minimum of 100 feet to a maxmium of 2,208 feet (Naivuivui) in the north-west. Slopes are mostly smooth but often steep. The Saru Creek flows in a south-westerly direction and provides the water for the township of Lautoka. The water is piped from the Public Works Department dam.

The photographs were taken soon after the end of the wet season and for this reason there is no evidence of the annual burning of the land.

The rocks of the area were formed during the Pliocene period at a time when there was widespread volcanic activity associated with uplift. The rock series is known as

* Assistant Conservator of Forests.

Koroyanitu and consists of flow aggregates and tuff with a variety of specialised andesites.

From the aerial photographs, four main vegetation types have been identified. It is interesting that classification on that basis reflects the relative fertility of the soil, and consequently forms an "economic" division on which plans for land-use, or from a forestry point of view, planting schemes, can be based.

Vegetation Type 1—*Lemon Grass—Cymbopogon citratus*.—This may be identified from photographs as a grassland type of coarse texture and medium colour. The Lemon Grass grows in this area in association with Gasau (*Miscanthus japonicus*) which is rather commoner on the lower hill slopes and valleys. The association is one of tall grasses varying from 4-8 feet in height. A few Guava (*Psidium guajava*) and other shrubs are commonly seen above the grasses. Form is useful in identification as the appearance of the grass and shrubs is uneven.

Texture and form are the most important identification factors. Colour is unreliable due to the topography and the fact that all photography took place before 10 a.m. daily when the sun was low on the horizon. The vegetation on the sunny side of the hills may in error be casually identified as a different type to that on the shady side due to differences in reflection. Also Guava shrubs on the sunny side throw shorter shadows which may be below the critical visible size, whereas the converse is true for shrubs on the shady side. This often gives a most misleading difference in density of stocking and may cause errors in type identification.

Vegetation Type 2—*Mission Grass—Pennisetum polystachyon*.—This may be identified as a grassland type of even texture and light colour. *P. polystachyon* forms an almost pure crop which is about 2-6 feet in height. Other vegetation mixed with it is of little significance for identification purposes.

To avoid errors it should be noted here that texture varies according to the distance from the centre of the photograph; the nearer to the edge of the photograph the rougher will be the appearance of the texture.

Vegetation Type 3: *Fernland*.—The vegetation on this area consists of mixed ferns among which *Pteridium aquilinum* and *Gleichenia linearis* are dominant. Both of these species rarely exceed two feet in height and give complete though light cover to the soil. *Causarina equisitifolia* is found in this vegetation type and may be readily identified by its distinct form. It is probable that the climatic climax for these areas is a Casuarina forest, but that its attainment is prevented by fire.

Type 4—*Forest or Shrub Cover*—Where trees or shrubs exceed 50 per cent of the visible vegetation this is termed tree or shrub cover.

Following the construction of a map and the delineation of the vegetation type boundaries the area was ground checked for accuracy. The actual boundaries showed considerable general resemblance, though there were minor differences. Study of the photographs revealed that several errors had been made due to the lack of experience in this work, and that these errors were avoidable. However, the study was a valuable one and showed that vegetation types followed geological and soil differences. Vegetation type 1 was found over tuffs, where the better soils were to be found, and in valley situations in the region of colluvial soils. Vegetation type 2 indicated areas of soil degradation almost certainly brought about by annual burning. It appears probable that these areas were vegetation type 1 at some earlier date. Vegetation type 3 is found on the andesitic lavas. These rocks weather to an infertile dark red-brown soil having a high ferric iron content and a low base status. The terraced effect often seen in photos of these areas is probably due to ridges of lava flow accentuated by the effects of erosion.

It may be mentioned that shrub cover can be subdivided, and it should be possible with adequate local knowledge and field checking to distinguish areas of Guava, Vai-vai (*Leucæna glauca*), Bamboo and possibly other types.

The Lewa Valley.—The second study was a serious attempt to apply the findings of the original study and to test their efficacy and general application to other localities.

Some years previously it had been noted on tour that areas of fern country existed in the vicinity of the koro of Lewa, and as this vegetation indicates land that is particularly suitable for the economic planting of Pinus spp. (mainly *Pinus caribæa*) an attempt was made to assess the areas of suitable soils.

From a close examination of the aerial photographs it appeared that between Lewa and Nadarivatu, a walking distance of about 8 miles following the valley of the Nukunuku Creek, of a total of 2,100 acres of open country there was nearly 1,300 acres of suitable fern land for Pine planting. The vegetation types discerned were similar to those of the Lautoka area.

Vegetation Type 1—*Gasau—Miscanthus japonicus*.—The type is dominated by the Gasau and larger grasses and usually includes mixed small bushes among which Guava is prominent.

Vegetation Type 2—*Mission Grass—Pennisetum polystachyon*.—This type is completely dominated by the Mission Grass.

Vegetation Type 3—*Fernland*.—The dominant fern on this occasion was *Pteridium aquilinum*, under which very stunted Tobacco weed (*Elephantopus mollis*) is very common.

Vegetation Type 4—*Vuga—Metrosideros polymorpha*.—This is distinguished by a light cover of stunted bushes consisting mainly of Vuga (*Metrosideros polymorpha*) mixed with ferns, herbs and grasses in the herb layer which includes Bracken (*Pteridium aquilinum*), Mokomoko (*Dryopteris microtricha*), Tobacco weed (*Elephantopus mollis*), two common grasses (*Paspalum orbiculare* and *P. conjugatum*), Blue Rats Tail (*Stachytarpheta urticæfolia*). This formation would appear to be caused by the clearing of forest for planting food crops, followed by burning and grazing which prevent the return to high forest. This vegetation type would appear to occur where the natural recovery of the soil is normally very slow following denudation.

Detailed ground checks revealed that only minor revisions were necessary in the original assessment and the work was of considerable value in formulating a forest plantation scheme aimed at alleviating the deficiency of softwood production in Fiji.

Nausori Highlands.—Continuing the search for elevated areas of infertile soils for use as Pine plantations, an area of land in the Nausori Highland was located solely by the use of aerial photographs. A suitable area of about 3,000 acres was located and adjacent areas of forest and grasslands were examined on aerial photographs. This was followed by a ground reconnaissance which confirmed the boundaries and areas arrived at by the use of aerial photographs.

From the agricultural point of view it is interesting to note that two further distinct associations were found on the aerial photographs which could also be located on the ground. The first was a marsh association (species unidentified) found in patches on the Nausori Highlands and the second was an association of short grasses on the bluffs on the eastern side of the Nausori Highlands near to and west of the koros of Nasaucoko and Wausi in the Sigatoka Valley.

Photography available in Fiji.—The photographs used in the foregoing studies are on the scale of 1/16,000. Practically the entire area of the dry and intermediate zones of the two principal islands of Viti Levu and Vanua Levu have been covered by the surveys of Messrs. Hunting Aero Surveys or Messrs. Adastra Ltd. at this scale, and complete coverage of the entire group at a scale of 1/50,000 has also been carried out by Messrs. Adastra Ltd. For the interpretation of grasslands these latter photographs have not yet been examined carefully but from preliminary observations it would appear that the reduction of scale renders the distinguishing of grassland types more difficult to determine and delineation of their boundaries less accurate, but used in conjunction with the 1/16,000 scale they are a great help in ground reconnaissance.

Conclusion.—The following types of vegetation which are of particular interest to the agriculturalist can be simply distinguished on aerial photoraphs of the dry and intermediate zone.

Vegetation Division.	Sub-divisions.	Principal identification features.
(1) Small tree and shrub areas.	(*a*) Guava areas.	Form and Texture.
	(*b*) Vaivai (*Leucæna glauca*).	Form and Texture.
	(*c*) Vuga open forest (*Metrosideros polymorpha*).	Form and Colour.
	(*d*) Bamboo (*Bambusa* spp.).	Form and Colour.
(2) Tall grasses.	(*a*) Fijian reed (*Miscanthus japonicas*).	Form.
	(*b*) Citronella grassess (*Cymbopogon* spp.).	Form.
	(*c*) Mission grass (*Pennisetum polystachyon*).	Texture and Colour.
(3) Short grasses, sedges and reeds.	(*a*) Short hill grasses of Sigatoka Valley (spp. unidentified).	Texture and Colour.
	(*b*) Marsh country.	Texture and Colour.
(4) Fern country.	(*a*) Bracken (*Pteridium aquilinum*).	Colour and Texture.
	(*b*) Qato areas (*Gleichenia linearis*).	Colour and Texture.

The art of interpretation is a skilled one and it should not be imagined that the technique can be acquired overnight. The ability to interpret aerial photos depends *inter alia* on the speed and accuracy with which the interpreter can recognise and distinguish form, colour and texture. Great importance is attached to the use of aerial photographs in the field so that the interpretations may be ground checked and correlated. The above list is an indication of what types can be distinguished given a general knowledge of the vegetation in the two zones. With greater local knowledge it should be possible to extend and improve the interpretations and apply them to some particular form of land use.

PASTURE IMPROVEMENT . . .

FODDER AND PASTURE INVESTIGATIONAL WORK AT SIGATOKA 1949-53

I. FODDER GRASSES AND LEGUMES

BY W. J. A. PAYNE, W. I. LAING, N. S. MILES AND R. R. MASON

A series of fodder and pasture investigations that were begun at Sigatoka in 1949 *or* 1950 *have been completed. It is therefore appropriate to evaluate the results of this investigation together with the results of observational trials, field observations, and subjective opimons arrived at after four years experience of pasture management at Sigatoka Agricultural Station.*

Unfortunately the interpretation of results of pasture investigations at one centre in Fiji cannot be translated into management practices that can be put into operation throughout the Colony. There are two distinct climatic zones, a wet zone characterized by tropical rain forest, and a dry zone characterized by savannah grassland, but there are also many micro-climates within these two major climatic zones.

Cultural and management practices that are found to be satisfactory at Sigatoka are likely to be of some utility throughout the dry zone of the Colony, that is in most of the area covered with natural grassland or *gasau* reed, but may not be of any value in the wet zone or tropical rain forest area. As, however, with the exception of dairy stock, the majority of the Colony's livestock are maintained in the dry zone results from Sigatoka are likely to be of some significance to the Colony's stock farmers.

The work at Sigatoka has been divided into three sections:—

(*a*) Fodder grasses and legumes suitable for cutting, grazing, or conservation,
(*b*) pasture grasses and legumes suitable for inclusion in any system of "ley" farming, and
(*c*) pasture grasses and legumes suitable for permanent hill grazings.

It has been found to be convenient to deal with these three sections in three separate articles. This article will deal with fodder grasses and legumes.

Work on fodder crops has been carried out at all Departmental Stations in the past, and at Sigatoka some fodder plants were introduced during the thirties and forties as part of the plant introduction programme and some observations were made on their growth, yield, and palatability. Valuable evidence on yield and chemical composition of several fodder plants in Fiji was obtained at one station, (Parham (1948)). Prior to 1949 elephant grass (*Pennisetum purpureum*) and guinea grass (*Panicum maximum*) pastures had been established as had plots of stylo (*Stylosanthes gracilis*), puero (*Pueraria phaseolides*), Kavirondo sorghum (*Sorghum verticiflorum var. Kenya*), pigeon pea (*Cajanus cajan*), and mauritius bean (*Mucuna aterrima*) and cowpea (*Vigna catiang*) had been usd as dual purpose green manure or fodders for many years.

RESULTS 1949-53.

Work was concentrated on the two fodder grasses that were already giving good results on the station, elephant grass and Kavirondo sorghum, but many new species were introduced during this period and trials and observations were made using the following:—

Species.	*Common Name.*
GRASSES—	
Pennisetum purpureum	Elephant grass.
Pennisetum polystachyum	Mission grass.
Tripsacum laxum	Guinea grass.
Panicum maximum	Guatemala grass.
Panicum maximum var. coloratum	Purple top guinea grass.
Hyparrhenia rufa	Jaragua grass.
Sorghum verticiflorum var. Kenya	Kavirondo sorghum.
Saccharum sinense	Uba cane.
LEGUMES—	
Desmodium uncinatum	Spanish clover.
Cajanus cajan	Pigeon pea.
Acuan virgatus	Desmanthus.
Leucæna glauca	Vaivai.
Stylosanthes gracilis	Stylo.
Peuraria phaseolides	Puero.
Centrosema pubescens	Centro.
Calapagonium muconoides	Calapo.
Indigofera endecaphylla	Creeping indigo.

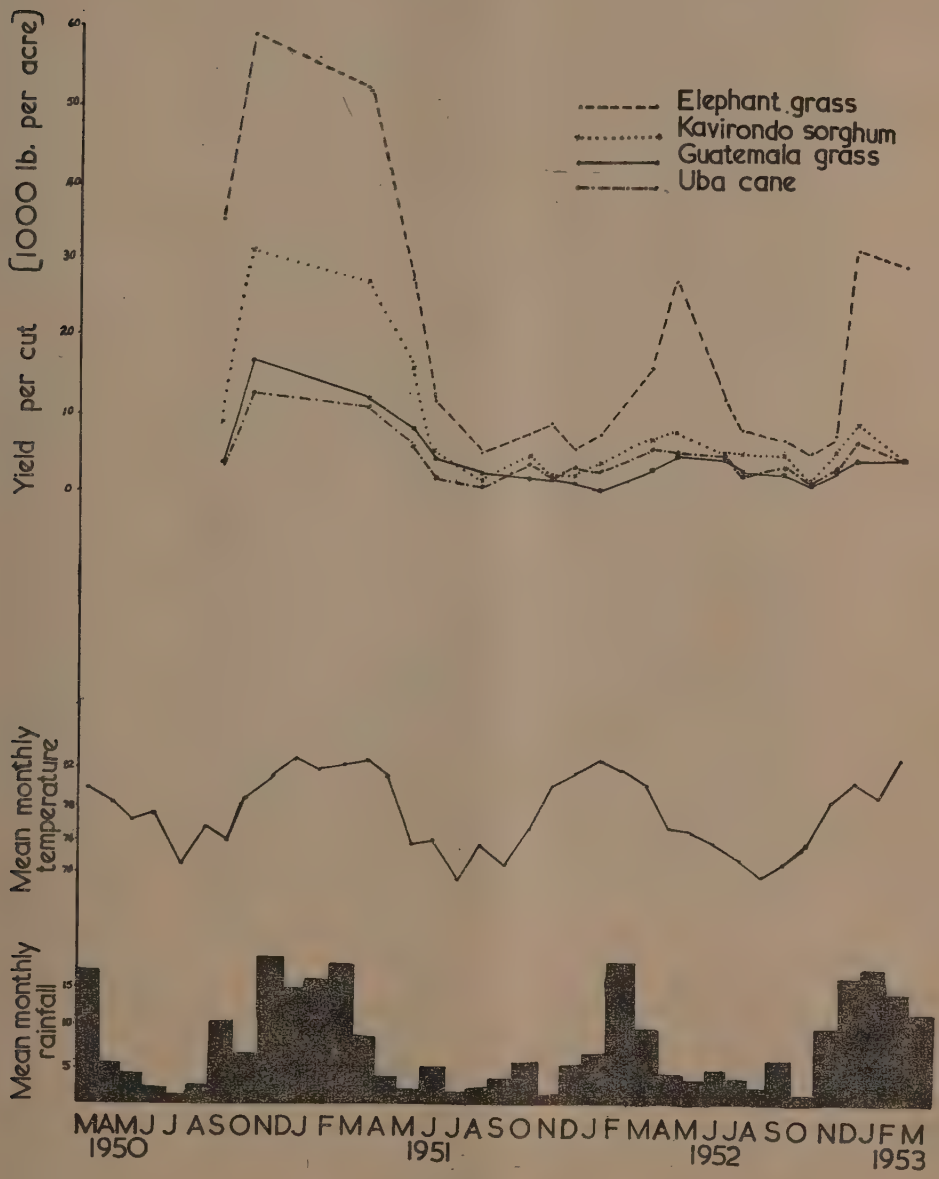
Yield per cut (1000 lb. per acre)
Elephant grass
Kavirondo sorghum
Guatemala grass
Uba cane
Mean monthly temperature
Mean monthly rainfall
MAMJ J ASONDJ FMAMJ J JASONDJ FMAMJJA SO NDJFM
1950
1951
1952
1953

Diagram 1.

Introduced species were first planted out in introduction plots. These consisted of 6 x 3 feet plots in which the introduced grass or legume was sown or planted. Each species was cut at approximately monthly intervals for three years and considerable data was collected on wet yield, seasonal periodicity in yield, flowering period, wet resistance, and drought resistance. No fertilisers were applied to the plots throughout this period. The yield per acre of fresh material of some of the different species for the years 1950-52 is given in Table 1 and some information on seasonal growth during 1952 is given in Table 2.

TABLE 1.

YIELD PER ACRE ('000 lb) OF CERTAIN FODDER GRASSES AND LEGUMES DURING THE PERIOD 1950-52.

Fodder.	Year. 1950	1951	1952
Guinea	221	127	110
Purple top guinea	147	100	105
Jaragua	106	151	169
Mission	161	218	185
Creeping indigo	19	67	50
Spanish clover	25	47	46
Puero (Hawaiian)	30	40	42
Puero (B.W.I.)	31	59	26
Vaivai	30	64	41
Stylo	22	54	39
Desmanthus	47	121	39
Centro	40	57	37

TABLE 2.

SEASONAL YIELD OF CERTAIN FODDER GRASSES AND LEGUMES DURING 1952 (PERCENTAGES OF TOTAL YIELD).

Fodder.	Wet season. November-April.	Dry season. May-October.
Guinea	79	21
Purple top guinea	74	26
Jaragua	68	32
Mission	79	21
Creeping indigo	67	33
Spanish clover	78	22
Puero (Hawaiian)	60	40
Puero (B.W.I.)	64	36
Vaivai	67	33
Stylo	72	28
Desmanthus	64	36
Centro	71	29

It will be seen from these two tables that some of the plot yields were very high, that in general the legumes yieded a great deal less wet material than the grasses, but that the yield was less seasonal. Without manuring grass yields tended to decline over the three year period while legume yields fluctuated widely. It is reasonable to assume that a mixture of fodder grass and legume would exhibit less " seasonal " swing in yield and maintain yield more consistently over a three year period.

Elephant grass was not grown in the introduction plots but it was grown in a replicated trial, and out in the field both as a component of pasture and as a pure stand (Plate 1). The replicated trial was designed to compare the productivity of elephant grass with three other tall fodders, Kavirondo sorghum, Guatemala grass, and Uba cane. The trial was laid out as a 4 x 4 Latin square the grasses being hand planted from clone material on March 20th 1950 at 3.3 feet apart in such a way that they could be cross blocked for cultivation purposes, and after establishment they were cut at approximately six weekly intervals. Dead plants were replaced from time to time.

It was obvious that the method of planting suited elephant grass better than the other grasses and thus gave it an initial advantage. Table 3 gives details of the yield per acre per year of the four fodders.

TABLE 3.

MEAN YIELD PER ACRE PER YEAR ('000 LB) WET MATERIAL.

Fodder grass.	Leaf.	Total.	Percentage leaf in total.
Elephant grass	64	85	75.3
Kavirondo sorghum	21	36	58.3
Guatemala grass	26	26	100.0
Uba cane	31	33	93.9

The yields of elephant grass leaf and whole plant were both significantly higher than that of the whole plant yield of the other fodder grasses. The seasonal nature of the productivity of all these grasses is well demonstrated in Diagram 1 and high yield apparently depends on adequate rainfall and possibly high temperature. The seasonal swing was not so marked during the relatively dry " wet " season of 1951-52.

An attempt was made to ensile elephant grass in a pit silo but it was not a very satisfactory feed as it was too old when ensiled.

Kavirondo sorghum was introduced into Fiji by Professor Paterson in 1945. It originated in Kenya and is said to be a natural hybrid between a native cultivated sorghum and *Sorghum verticelliflorum*. It appears to be a particularly valuable " catch " fodder crop for grazing or ensiling and several observational trials were conducted during the period 1949-50 in order to obtain data on the correct methods of management.

Plate 1.—A mixture of elephant grass ("Pennisetum purpureum") and centro ("Centrosema pubescens").

When field 13A was sown with Kavirondo sorghum on October, 1949, three seed rates were used, 12, 24 and 48 pounds per acre. Subsequent observations on the crop suggested that 24 pounds per acre, was the most suitable seed rate, the seed being sown in seven inch drills with an ordinary corn drill. Field 13B was sown with Kavirondo sorghum on November 14th, 1949, at the rate of 24 pounds per acre and seven legumes were broadcast in strips across the field. The seed rates are given in Table 4.

TABLE 4.

SEED RATES OF LEGUMES SOWN WITH KAVIRONDO SORGHUM IN FIELD 13B.

Legume.	Seed Rate lb/acre.	% Crude Protein D.M. Basis. Sampled 20/1/50.
Calapo	5	13.38
Centro	5	6.58
Stylo	5	6.56
Vaivai	30	6.28
Desmanthus	7.5	5.88
Pigeon pea	3	..
Puero	1	6.62

The field was strip grazed by the dairy herd at bi-monthly intervals but only centro, calapo, and stylo stood up to this form of

management. Plate 2. The field was first grazed six weeks after drilling and at two months samples were taken for crude protein analysis. Details given in Table 4, demonstrate clearly that the only legume that was making a substantial contribution to the fodder mixture at this stage was calapo on account of its rapid germination and growth. After six months the only legumes present were calapo, centro, and stylo. Calapo is now a weed in this field.

The use of Kavirondo sorghum as a cover crop was tested when field 18 was cleared and sown to grass on the eleventh of November, 1949. The seed mixture was four pounds guinea grass, four pounds centro, ten pounds Kavirondo sorghum, and two pounds Nadi blue grass. The field was first grazed on 14th December, 1949. All the Kavirondo sorghum had disappeared by the 1st of August, 1950, by which time a Nadi blue grass pasture was firmly established.

Plate 2.—Friesians strip grazing a temporary ley of Kavirondo Sorghum ("Sorghum verticiflorum var Kenya") at Sigatoka.

Pit silage was made from Kavirondo sorghum early in 1949, a sample taken in June, 1949, showed that the crude protein content was 8.0 per cent and the material was fed to both dairy cattle and pigs in November, 1949. Stack silage was made in January, 1950, but this was not a success on account of the poor compaction of the ensiled fodder. Molassed pit silage was made in December, 1949, using molasses at the rate of 10 pounds to 10 gallons of water for every ton of silage. This silage was fed to the young stock in 1950 and it was eaten quite readily.

A fertiliser trial on Kavirondo sorghum was laid down on the 14th of November, 1949. The layout was a 2^3 factorial design replicated four times. The effect of using three fertilisers was evaluated, sulphate of ammonia at two hundredweight per acre, superphosphate at one hundredweight per acre, and muriate of potash at one hundredweight per acre. The yields are given in Table 5. The effect of nitrogen on total yield of green material was highly significant at all levels, but the yield fell rapidly, being +4,534 pounds at the first cutting, +1,856

pounds at the second cutting and −447 pounds at the third cutting; the overall increase being 11.8 per cent. A second application of nitrogenous fertiliser would doubtless have maintained the increase through to the third cut. The application of nitrogen had no significant effect on the crude protein content. It was calculated that the application of nitrogen alone was an economic proposition. No other treatment gave a significant response.

TABLE 5.

GREEN WEIGHT YIELDS AND CRUDE PROTEIN CONTENTS OF KAVIRONDO SORGHUM GROWN IN A FERTILISER TRIAL.

	Yield lb/acre.			Crude Protein. % D.M.
Treatment.	4.1.50	13.4.50	17.7.50	4.1.50
Control ..	28,725	16,935	4,520	4.31
n	39,930	23,580	4,247	4.05
p	27,215	18,620	6,519	4.03
k	22,460	17,615	6,044	4.31
np ..	36,060	24,940	4,029	4.54
nk ..	41,750	24,120	5,118	4.56
pk ..	27,460	19,600	4,846	3.72
npk ..	39,700	23,745	3,213	4.24

Guatemala grass.—Only yielded approximately one third of the wet material that elephant grass did in the replicated trial. It is not so palatable as elephant grass at Sigatoka and the cattle will only eat it if no other fodders are available.

Uba cane also yielded much lower than elephant grass and does not appear to have any particular value as a fodder crop in the dry zone.

Guinea, Purple top guinea, Jaragua and Mission grasses have not been used on a field scale as fodder grasses, though small blocks of guinea, jaragua, and mission have been planted out in the nursery and horse hoed continuously. They all show promise but no information on comparative yields is available. From field observations purple top guinea does not appear to be as well suited to the local environment as do local strains.

Spanish clover has only been studied on a plot scale as a fodder, but it has been used in the field as a pasture legume. It apparently stands up to grazing and is palatable, but does not make a good mixture with any of the associated grasses so far tried. It seeds quite freely.

Puero has been studied on a plot and a field scale. It is not very palatable and in the dry season it is sometimes severely defoliated by leaf rolling caterpillars. It does not appear to be very valuable as a fodder legume in the dry zone.

Plate 3.—Vaivai (" Leucæna glauca ") grown as a drilled crop at Sigatoka.

Vaivai is a dominant species over considerable areas of the hill land in the dry zone. Plate 3. It is highly thought of by local stockmen and the stock in the vaivai areas look extremely well fed. It is very palatable and seeds profusely, though it is not particularly easy to establish on the hills. It is very doubtful whether it can be grown successfully in a mixed grass legume association, and is probably better grown as a pure stand. A great deal of work has been done in Hawaii on this species (Takahashi and Ripperton (1949)) and by using the Hawaiian techniques it has been established as a drilled fodder crop on the alluvial soils at Sigatoka (Payne (1954)). It contains a substance known as mimosine that causes toxic symptoms in non-ruminants and it should not be fed to horses or to breeding pigs.

Pigeon pea grows well at the station and the Hawaiian variety that was introduced in 1950 seeds profusely. It was grown on a field scale in 1950 and 1951, but experience has shown that it is very unpalatable and the stock can only be induced to eat it when it is in bloom. Zebu-type stock are more partial to it than European type, but this may only be because they are more used to browsing.

Desmanthus has been studied on a plot scale and has been grown out in the field together with Kavirondo sorghum. It appears to be quite palatable but will not stand up to grazing. It might be a useful drilled crop to cut for fodder.

Stylo has been studied in plots and out in the field. Unfortunately it is not very palatable.

Centro grows well in a grass-legume mixture, and has been grown together with Kavirondo sorghum on a field scale. It seeds quite freely, and its palatability is fair. It is undoubtedly one of the most useful legumes at present grown on the station as it grows vigorously on both the alluvial soils and the hills.

Calapo is an annual which seeds very freely. It almost entirely disappears during the dry season. It has been studied both in plots and on a field scale. Unfortunately it is very unpalatable and where it has been used on a field scale it is rapidly becoming a serious weed. This is particularly so in rice.

Creeping indigo has only been studied on a plot scale as a fodder but it has been used as a pasture legume. There are reports that this species can cause toxic symptoms in stock. A local toxicity trial carried out at Sigatoka gave inconclusive results (Payne and Naidu (1955)). The species is vigorous, mixes well with grasses, is very palatable, and sets viable seed at Sigatoka.

DISCUSSION.

Elephant grass is undoubtedly the most suitable large fodder grass for the dry zone. It is easily established and can be planted in the same way as sugar cane, the most suitable time for planting being at the end of the dry season. Its yield is very high even without fertilisers for two or three years on the alluvial soils at Sigatoka, and although there is a very large seasonal swing in productivity, growth does not cease during the dry season. During the drought of 1953 elephant grass was one of the few plants still producing some fodder. According to the Hawaiian workers Wilsie and Takahashi (1934) it grows well under irrigation despite the fact that it is drought resistant. Observations at Sigatoka suggest that it responds well to nitrogenous fertilisers but no replicated trials have been laid down.

No attempt was made during 1949-53 to grow this grass with a legume but it is probable that it will mix well with legumes with a creeping habit as Warmke *et al.* (1952) have shown that both kudzu and creeping indigo form a stable mixture with it and that the legume mixtures outyielded the grass by itself. A new experiment has been laid down at Sigatoka to see how well the legumes centro and creeping indigo do mix with elephant grass.

Elephant grass can be cut or grazed but if it is grazed it must be rotationally grazed as set stocking will soon ruin it. It has been shown at Sigatoka that it can be close folded at three to four week intervals, but it is better to cut rather than graze it immediately after establishment, as cattle tend to pull

the young plants out. The feeding value depends on the stage at which it is cut or grazed and a great deal of investigational work has been done on this in Hawaii and Trinidad. Paterson (1939) considers that elephant grass outyields other common tropical fodder grasses in crude protein content if it is cut at the correct stage and he recommends four cuts a year. This may be satisfactory if it is always cut but is definitely not satisfactory if it is grazed as the grass becomes too long and fibrous for the cattle.

Kavirondo sorghum is a very useful " catch " fodder crop as it grows so rapidly and at the beginning of the wet season will provide grazing within a few weeks of sowing. It is also very drought resistant. It is not suitable however for permanent fodder areas as it does not persist under constant cutting or grazing. It is easily established from seed and should be drilled at the rate of 24 pounds per acre with a corn drill or broadcast at a slightly higher seed rate. It is difficult to find a suitable legume quick growing enough to mix with it and it is probably better grown as a pure stand. It can be used however as a nurse crop for a grass or grass and legume mixture. At Sigatoka it has been used successfully as a nurse crop for Nadi blue grass (*Dichanthium caricosum*) and in Kenya (Kenya (1946)) for Rhodes grass (*Chloris gayana*). It responds very well to nitrogenous fertiliser, and is very palatable and unlike other sorghum is not toxic to stock at any stage of growth (Parham (1947)). Little is known of its feed value but a report by Edwards (1941) from Kenya states that it has a crude protein content of 7.4 per cent after eighteen weeks growth. Although it could be very valuable it is unlikely to be widely grown in Fiji as its use does not fit into any of the existing patterns of farming. The advantages and disadvantages of the smaller fodder grasses such as guinea, mission and jaragua and the legumes will be discussed in the second paper as at Sigatoka they are used as pasture rather than fodder grasses and legumes.

SUMMARY.

1. Field trials and observations at Sigatoka have shown that elephant grass (*Pennisetum purpureum*) is outstanding as a fodder crop in the dry zone. It has a very high yield, grows well in the dry season, can be cut or rotationally grazed and is very palatable. No investigations have yet been completed on its nutritional value, or as to whether it mixes well with legumes or on its response to nitrogenous fertiliser.

2. Kavirondo sorghum (*Sorghum verticiflorum var. Kenya*) is an excellent catch fodder crop but is not suitable for inclusion in a long ley.

3. Guinea grass (*Panicum maximum*), jaragua grass (*Hyparrhenia rufa*) and mission grass (*Pennisetum polystachyum*) are all possibly useful long term fodder crops.

4. The legumes stylo (*Stylosanthes gracilis*), puero (*Pueraria phaseolides*) and pigeon pea (*Cajanus cajan*) are not very palatable but they all grow well at Sigatoka. Calapo (*Calapagonium muconoides*) is not palatable and seeds so profusely that it may become a weed and should definitely not be distributed to farmers.

5. Desmanthus (*Acuan virgatus*) and vaivai (*Leucæna glauca*) are very palatable and vaivai may be a useful fodder for the dry zone.

6. Spanish clover (*Desmodium uncinatum*) yields quite well and seeds freely but it does not appear to be very useful for inclusion in fodder mixtures.

7. Centro (*Centro pubescens*) is fairly palatable, stands cutting and/or grazing and produces some green feed during the dry season. Creeping indigo (*Indigofera endacaphylla*) is very palatable. Both may be suitable for inclusion in legume fodder mixtures. There is however some overseas evidence that creeping indigo may be toxic to livestock under certain conditions and it should not be distributed to farmers until further local evidence is available.

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II. PASTURE GRASSES AND LEGUMES SUITABLE FOR INCLUSION IN A SYSTEM OF "LEY" FARMING

BY W. J. A. PAYNE, W. I. LAING, AND N. S. MILES

In 1949 there were no pastures at Sigatoka that had been laid down specifically as short-term leys, though there were pure stands of Nadi blue grass (Dichanthium caricosum), para grass (Brachiaria mutica) and guinea grass (Panicum maximum) that had been laid down as permanent pastures. The guinea grass pasture was very poor and full of weeds, the para grass pastures were more productive but were also full of weeds and the blue grass pastures were not very productive though comparatively free of weeds.

It was decided to attempt to establish an alternate husbandry rotation on the station and as a consequence investigations were directed towards obtaining information on species of grasses and legumes that would be suitable for inclusion in short and long term leys.

RESULTS 1949-53.

As reported in the first paper (Payne *et al.* (1955)) plant introduction plots were established in 1949. Plate 4. Table 1 gives a list of grasses and legumes that were sown or planted out in these plots in addition to those reported on in the first paper. Tables

Plate 4.—Visitors inspecting the plant introduction plots at a Sigatoka Field Day.

2 and 3 give details of the yield per acre of fresh material during the years 1950-52 and Table 4 gives some information on seasonal growth. As with the fodder grasses and legumes there is a marked seasonal variation in growth, but even without fertilisers yields did not decline over the three year period as they did with some of the fodder grasses. In many cases although yields were much lower initially than those of the fodder grasses, they increased over the three year period. There is of course no clear distinction between fodder and ley grasses and legumes and some species many be useful in both roles, but it would appear that in general large fodder grasses deplete fertility more quickly than do the smaller grasses.

TABLE 1.

A LIST OF PASTURE GRASSES AND LEGUMES ON WHICH OBSERVATIONS WERE MADE IN THE INTRODUCTION PLOTS DURING THE PERIOD 1950-52.

Species.	*Common name.*
GRASSES—	
Paspalum scrobiculatum	Scrobic.
Paspalum dilatatum	Dallis grass.
Paspalum spp.	Creeping or prostate paspalum.
Paspalum galmarra	Russell river grass.
Paspalum urvillei	Vasey grass.
Paspalum notatum	Black paspalum: Bahia grass.
Urachloa pullulans	Hawaiian para grass.
Urachloa spp.	Little para grass.
Brachiaria brizantha	Kifuta grass
Brachiaria mutica	Para grass.
Brachiaria distachya	Thurston: Dry zone sour grass.
Digitaria melangiana	Woolly finger grass.
Axonopus affinis	Narrow leaf carpet grass.
Axonopus spp.	Koronivia carpet grass.
Axonopus spp.	Sigatoka carpet grass.
Andropogon pertusus	Barbados sour grass.
Amphilophis glabra	Caboni blue grass.
Ischæmum aristatum	Batiki blue grass.
Ischæmum timorense	Waidoi grass.
Dichanthium caricosum	Nadi blue grass: Antigua hay grass.
Dichanthium spp.	Vuda blue grass.
Dichanthium annulatum	Many headed blue grass.
Dichanthium sp.	Vatia blue grass.
Melinis minutæflora	Molasses grass.
Echinochloa crus-galli	Barnyard millet.
Chloris gayana	Rhodes grass.
Chloris cynodontoides	Star grass.
Chloris virgata	Feather finger grass.
Penniselum ciliare	African foxtail.
Pennisetum pedicellatum var.	Kyasuwa cream.
Pennisetum clandestinum	Kikuyu grass.
LEGUMES—	
Dichanthium spp.	Samoan clover.
Desmodium triflorum	
Desmodium heterophyllum	Fiji trefoil.
Desmodium canum	Kaimi clover.
Desmodium discolor	Discoloured clover.

TABLE 2.

YIELD OF GRASSES IN THE TWO SQUARE YARD INTRODUCTION PLOTS 1950-52.

('000 LB OF GREEN MATERIAL PER ACRE).

Species.	1950	1951	1952
Vasey	..	18	106
Vuda blue grass	62	108	106
Nadi blue	72	69	100
Kifuta	73	122	100
Many headed blue	66	77	99
Woolly finger	93	91	98
Barbados sour grass	35	59	94
Molasses	57	59	79
Russell river	78	73	79
Vatia blue	..	..	74
Hawaiian para	62	93	70
Barnyard millett	26	21	69
Caboni blue	39	42	64
Carpet grass: Sigatoka	24	39	62
African foxtail	45	33	62
Batiki blue	42	50	62
Little para	100	67	57
Feather finger	..	..	56
Para	105	78	52
Fine leaf carpet grass	52	..	52
Black paspalum	41	56	44
Dallis	58	35	43
Creeping paspalum	42	..	41
Rhodes	107	85	39
Kikuyu	..	..	37
Scrobic	..	..	35
Waidoi	38	26	27
Carpet grass: Koronivia	39	..	17

TABLE 3.

YIELD OF LEGUMES IN THE INTRODUCTION PLOTS 1950-52.

('000 LB OF GREEN MATERIAL PER ACRE).

Species.	1950	1951	1952
Desmodium spp. (Samoan clover)	..	..	33
Desmodium triflorum	..	..	16
Fiji trefoil	..	..	9
Kaimi clover	8	0.7	10
Discoloured clover	..	1	3

A trial was laid out early in 1950 to compare the yield of wet material and observe the aggressiveness of six grass species that appeared at that time to be suitable for inclusion in a three year ley. The layout was a six by six latin square and all the grasses were planted out vegetatively at the rate of 16,000 plants per acre, *Desmodium heterophyllum* was planted out at the rate of 1,400 plants per acre in each plot as soon as the grasses were established. The grasses were cut at approximately eight week intervals. Details of average yield are given in Table 5. The production of woolly finger was significantly higher than that of any of the other grasses. Nadi blue was the most aggressive, but its yield declined with age. Woolly finger and all the other grasses with the exception of Nadi blue combined well with the *Desmodium heterophyllum*. The two bunch grasses guinea and dallis were penalised by the method of planting, and they were both susceptible to competition although once guinea was well established its yield did not decline further.

TABLE 4.

SEASONAL YIELD OF GRASSES AND LEGUMES IN THE INTRODUCTION PLOTS.

(EXPRESSED AS PERCENTAGE OF TOTAL).

Species.	Nov.-April.	May-October.
GRASSES—		
Vasey	81	19
Vuda blue grass	51	49
Nadi blue	68	32
Kifuta	66	34
Many headed blue	61	39
Vatia blue	63	37
Woolly finger	64	36
Barbados sour grass	67	33
Molasses	66	34
Russell river	58	42
Hawaiian para	61	39
Batiki	51	49
LEGUMES—		
Desmodium spp. (*Samoan clover*)	59	41
Kaimi clover	81	19
Discoloured clover	52	48

NOTE.—The figures for the majority of species listed in this table were calculated from a total of three years data with the exception of the figures for Vasey and discoloured clover (two years) and Vatia blue and *Desmodium spp.* (one year).

TABLE 5.

AVERAGE ANNUAL YIELD OF GRASSES IN THE PASTURE GRASS YIELD TRIAL.

Species.	Yield per acre per year. ('000 lb)
Woolly finger	34
Para	23
Nadi blue	20
Little para	16
Guinea	13
Dallis	9

A pasture grass and legume observational trial was also laid out in Field No. 4 to test 36 grass-legume mixtures under actual grazing conditions. Six different grasses were sown one way across the field and six different legumes the other way to form a chequer board type of trial. All grasses and legumes were planted from seed with the exception of creeping indigo. The six grasses were guinea, para, little para, rhodes, mission, and a mixture of little para and para, and the six legumes were creeping indigo, spanish clover, kaimi clover, *Desmodium heterophyllum*, calapo, and centro. Of the grasses only guinea, para, mission, and little para established well, and only guinea and para have held their own after three years grazing and only guinea is productive in the dry season. Of the legumes, creeping indigo, *Desmodium heterophyllum* and centro have held their own or are spreading. The stocking rate of the whole area increased from 167 stock units in 150 days in 1950 to 337 units in 240 days in 1952. Observations were made in this field of the palatability of the different mixtures by counting the number of cows on each section at specific times. It was found that by this test guinea, para, and centro were particularly palatable.

An observational trial on the effect of the application of sulphate of ammonia and basic slag, discing and the spreading of manure by harrowing on a Nadi blue grass pasture was carried out during the 1952 dry season. Discing was found to depress yield and this is not surprising as it was carried out in the dry season, spreading manure seemed to assist the pasture and there was a marked response for a short period to the application of small amounts of sulphate of ammonia. A response to basic slag was not apparent.

Considerable practical experience has been gained during these years in the laying down and management of pastures and details of the leys that have been laid down are given below :—

Field 2—

(*a*) This was planted with guinea crowns in January, 1949. Approximately one third of the field was a complete failure and was replanted with guinea seed and centro in January, 1951. The guinea seed completely failed to germinate but the centro established itself and formed quite a good cover before the field was ploughed in 1952. It was possible to locate the area sown to centro in the maize crop planted in the field during 1953, as the maize in that part of the field had darker green leaves than the remainder of the crop. The yield of guinea grass was never high and gradually declined until it became negligible when the field was ploughed in 1952.

(*b*) This was planted with Nadi blue grass cuttings in February-March, 1949. At first there was a great deal of weed, particularly sensitive grass (*Mimosa pudica*) but by mid-1951 there was a pure stand of blue grass. This was very intensively stocked and continuously harrowed in order to " open up " the turf, and it did well in the wet seasons but produced little growth during the dry season.

Field 4—

(*a*) Approximately one acre was planted with vaivai (*Leucæna glauca*) and two acres with elephant grass (*Pennisetum purpureum*). Although both these plants are usually utilised as fodder plants this area was laid down for grazing and may be considered as a pasture. The vaivai seed was treated and drilled with a maize drill. Some details of the methods used are given in a recent note by Payne (1954). The elephant grass was planted from cuttings. The vaivai was a moderately good plant and the elephant grass very good. Both

species have stood up very well to continuous rotational grazing over a two year period although both the vaivai and the elephant grass have become full of weeds.

(*b*) A pasture was established in a rather novel way. The field was ridged on 19th May, 1951, and ten hundredweight of para stems, and five hundredweight of *Desmodium heterophyllum* stems per acre were thrown along the ridges. The ridges were covered in and 20 pounds per acre of guinea seed were sown on top and harrowed in. The field was given five hundredweight basic slag per acre and is now a mass of legumes and on 30th April, 1953, it was estimated that the cover was fifty per cent sensitive grass, twenty per cent *Desmodium heterophyllum* and five per cent para. The amount of guinea grass present was insignificant.

Field 7—

(*a*) This part was sown with a mixture of six pounds of guinea and three pounds of calapo on 15th December, 1949. It was first cut for silage on 17th April, 1950, and unfortunately a great deal of the young guinea was dragged out by the mower. Details of the yield and the percentage composition of the pasture are given in Tables 6 and 7. The yield was measured by the use of cages placed in the field at random before grazing. After grazing the pasture inside the cage was cut back to the same level as the pasture outside. The position of the cages was altered at every grazing.

(*b*) This part of the field was sown with a mixture of six pounds of guinea and four pounds of centro at the same time and under the same conditions as section (*a*) and afterwards managed in approximately the same way. Details of yield and approximate botanical composition are also given in Tables 6 and 7. Yield was measured in the same way as on the calapo-guinea area. It will be seen that there was a high sustained yield in both these pastures, and less sea-

Plate 5.—A guinea (" Panicum maximum ") centro (" Centrosema pubescens ") pasture at Sigatoka.

sonal swing than is exhibited by single species in the plot. The guinea-centro mixture improved over the period 1950-52 at the expense of other species. This must be considered by far the most successful pasture established on the station to date, although it was susceptible to invasion by weeds and had to be managed carefully. Plate 5.

(*c*) On this part woolly finger grass was planted out on one half acre from cuttings. It yielded well and is very palatable and there is a good legume mixture the main constituent being *Desmodium heterophyllum* but it is now being invaded by Nadi blue grass and it is definitely not stable under continuous rotational grazing.

(*d*) Approximately one acre was planted with para grass from cuttings. The field is still very weedy but a considerable amount of *Desmodium heterophyllum* is present and the para grass is gradualy disappearing under continuous rotational grazing throughout the year. The interval between grazings varying from 21 to 28 days according to season.

Field 8—

An attempt was made to sow down a guinea-centro mixture under maize in 1951. This must be accounted a failure as only centro has survived. Hawaiian para, sown after the guinea also failed. The field is now a mixture of doub (*Cynodon dactylon*), sensitive, and centro.

TABLE 6.

APPROXIMATE YIELD OF CALAPO-GUINEA AND CENTRO-GUINEA PASTURES IN FIELD NUMBER 7. (LB GREEN MATERIAL PER ACRE).

Date.	Calapo-guinea.	Centro-guinea.
Sown Jan. 1950.		
17/4/50	13,441	13,500
May-Oct. 1950	9,531	6,438
Nov.-Apr. 1950-51	24,017	27,536
May-Oct. 1951	15,365	11,667
Nov.-Apr. 1951-52	10,630	16,200
May-Oct. 1952	16,700	16,100

Field 17—

This was sown down with a mixture of guinea, centro and Kavirondo sorghum (*Sorghum verticiflorum var. Kenya*) in January, 1953. Only a few plants of centro have survived. There is virtually no guinea or Kavirondo sorghum.

TABLE 7.

PERCENTAGE COMPOSITION OF CALAPO-GUINEA AND CENTRO-GUINEA PASTURES IN FIELD NUMBER 7.

Date.	Percentage.					
	Total Grass.	Total Legume.	Guinea.	Other Grasses.	Centro.	Sensitive.
CENTRO-GUINEA—						
Sown January, 1950.						
20th April, 1950	..	..	84	..	2	..
27th September, 1950	50	35	30	20	2	33
22nd March, 1951	70	30	32	38	8	22
20th October, 1951	77	23	33	44	23	..
23rd March, 1952	66	34	46	20	32	2
11th October, 1952	73	18	64	9	18	..
CALAPO-GUINEA—						
19th April, 1950	..	..	5	..	46	..
27th September, 1950	49	38	17	32	4	34
24th March, 1951	59	41	9	50	3	38
17th October, 1951	91	9	..	..	..	..
23rd March, 1952	74	26	15	59	8	18
*10th October, 1952	57	21	..	57	21	..

* Unsatisfactory sampling took place on this date.

Field 18—

This field was sown to guinea, centro, and Nadi blue grass using Kavirondo sorghum as a nurse crop. The seed rates were four pounds of guinea, four pounds of centro, two pounds of Nadi blue grass and ten pounds of Kavirondo sorghum. The mixture was sown on 11th November, 1949, and first grazed on 14th December, 1949. The Kavirondo sorghum had almost disappeared by 12th August, 1950, and by early 1951 Nadi blue was the dominant species.

The following observations on management have been made repeatedly :—

(*a*) That in rotationally grazed fields harrowing the dung soon after the cows have finished grazing an area is a most desirable practice.

(*b*) That in the wet season the fields should be topped occasionally with a mower. This quickly reduces the sensitive grass and other weeds. It is not generally a desirable practice in the dry season.

(*c*) That disc or heavy drag harrowing of Nadi blue grass pastures is desirable in the wet season, but not in the dry. Guinea pastures should not be disced or harrowed at any time.

(*d*) That pastures on the alluvial soils respond to the application of nitrogen (though the response has not been measured) and that the application of phosphate in the form of basic slag is very effective in increasing the amount of legumes in the sward.

(*e*) That "strip grazing" is very desirable in view of the marked seasonal productivity of most pastures. This permits the area grazed to be altered according to the amount of feed available.

(*f*) That arable crops following Nadi blue grass in the alternate husbandry rotation do not look as healthy or yield as well as those following other grasses.

DISCUSSION.

Evidence on the value of the different grasses and legumes for ley farming from the results of the different trials and observations is often contradictory but it is possible to select species that merit further trial on a field scale. These grasses are Nadi blue grass, Vuda blue grass, many-headed blue grass, Batiki blue grass, woolly finger grass, kifuta, molasses grass, dallis grass, Vasey grass Hawaiian para, para grass, barnyard millett, guinea grass, mission grass, jaguara, and the legumes are creeping indigo, Spanish clover, centro, *Desmodium spp.* (Samoan clover ?) and *Desmodium heterophyllum.*

Nadi blue grass yielded well in the introduction plots and the yield did not decrease over the three year period. It also did quite well in the pasture grass yield trial. It forms a close sward pushing out both weeds and legumes, though when it has received generous dressings of basic slag the legumes tend to come back. It is easily established from seed and can be established under a catch crop such as Kavirondo sorghum. It will stand up to very heavy grazing and constant cutting but is easily ploughed out. Arable crops do not appear to grow so well behind Nadi blue grass as they do behind some of the other grasses in the alternate husbandry rotation. It can be a useful grass in a ley provided that it is sown in a position where the soil does not dry out too much in the dry season. Its utility as a hill grass will be be discussed in the next paper.

Vuda blue grass and *many-headed blue grass* are similar to Nadi blue grass in most characteristics. Observation has shown that Vuda blue grass may be a little more drought resistant, so that its annual production of green feed per acre is slightly higher than that of Nadi blue.

Batiki blue grass only yields approximately half of the total yield of Nadi blue but it does not appear to be quite so seasonal in its growth. It is very palatable and forms a close sward. It is undoubtedly a very useful grass in the wet zone but its usefulness in the dry zone is doubtful. It should be grown in the dry zone for seed.

Woolly finger grass yielded well in the plots and its yield did not decline after three years. It is not as seasonal in its growth habit as Nadi blue and in the pasture grass yield trial yielded appreciably more than any other grass. It mixes well with legumes, is very palatable, seeds freely in the dry zone and can also be propagated by rhizomes. Unfortunately field trials have shown that it does not stand up as well as some of the other grasses to intensive rotational grazing though it is suitable for inclusion in a three year ley.

Kifuta yields well and is not as seasonal in its growth as some of the other grasses. It is only moderately palatable but seeds quite freely. It has not yet been sown or planted out on a field scale. It is reported from Queensland to cause photosensitisation troubles in cattle.

Molasses grass yields moderately well. It seeds well and is palatable, but it does not stand up well to intensive grazing.

Dallis grass only yielded moderately in the introduction plots and very poorly in the pasture grass yield trial but it is very palatable. It is possible that the cutting procedure in both trials penalised this grass.

It has been noted that it generally appears to be growing better in the dry than in the wet season and it might be a useful grass in a mixed ley for providing some winter "keep".

Vasey grass was not planted out in the introduction plots until late 1951. It yielded very well during 1952 but showed a very marked seasonal growth. Its palatability is unknown.

Hawaiian para yielded well and is moderately palatable. It seeds well but it has not yet been found possible to establish a stand of it in the field from seed.

Para grass yielded well during the first year but its yield rapidly declined. It is widely grown in the wet zone but does not appear to be so useful in the dry zone except in wet areas. Experience in the field has shown that it grows well during the wet months and virtually disappears during the dry season. It is very palatable and responds well to nitrogenous fertilisers in the field though no replicated trials have been carried out on the extent of its response or on the economics of fertilising it.

Barnyard Millet is a weed in many arable crops in the dry zone but it is a useful component of newly established pastures as it is very palatable and grows rapidly. It will provide a cover and a considerable amount of feed more quickly than any other grass species. It might be a useful component of short term leys.

Guinea grass yields very well but its yield declines with age if it is not fertilised. It is very seasonal in growth producing a very large flush of grass in the months of December and January but it will also produce some growth during the dry season when most other grasses stop growing. It is a bunch type grass and needs a legume mixed with it or other grasses, otherwise it becomes weedy. The best pastures sown at Sigatoka during the years 1949-53 have been guinea-centro and guinea-creeping indigo pastures. One disadvantage of guinea is that it is particularly sensitive to management practices and bad management can soon spoil a good guinea pasture. It is very palatable and it must be rotationally grazed and not set stocked or it will be rapidly eaten out. The value of guinea grass in the dry zone is discussed more fully in the third paper.

Mission grass yields well and is palatable when young but quickly becomes stemmy. It has become a undesirable weed on the hills on the north coast of Viti Levu. Under the circumstance it is probably better not to use it in ley mixtures.

Jaragua yields well but little is yet known about the palatability of this grass or whether it will stand up to rotational grazing.

Desmodium spp. has not yet been identified but is possibly the legume known as Samoan clover. It yields better than most of the other Desmodium species and has a creeping habit not unlike centro. It could be a useful component of pastures but nothing is yet known as to its palatability or its ability to stand grazing.

It is cheaper to sow grass seeds for a ley than to plough in or plant cuttings or crowns so that all other factors being equal species that seed freely and produce viable seed are more valuable for leys than species that have to be planted out from cuttings or crowns. The blue grasses all seed freely and are easily established from seed. Guinea seeds very freely but the seed is not very viable (Motta (1955)) and this limits its usefulness in ley seed mixtures. Para seeds but not very freely and is always propagated from cuttings in Fiji.

In general, management practices that are desirable in the temperate zone are also desirable in the tropics but there are some exceptions and this type of information can only be found out by wider practical experience in the field.

SUMMARY.

1. A number of local and introduced grasses appear to be promising as components of leys. These include Nadi blue grass (*Dichanthium caricosum*), Vuda blue grass (*Dichanthium spp.*) many headed blue grass (*Dichanthium annulatum*), Batiki blue grass (*Ischæmum aristatum*), woolly finger grass (*Digitaria melangiana*), kifuta (*Brachiaria brizantha*), molasses grass (*Melinis minutæflora*), dallis grass (*Paspalum dilatatum*), Vasey grass (*Paspalum urvillei*),

Hawaiian para grass (*Urachloa pullulans*), para (*Brachiaria mutica*), barnyard millet (*Echinochloa crus-galli*), guinea (*Panicum maximum*), mission (*Pennisetum polystachyum*) and Jaragua (*Hyparrenhia rufa*).

2. A local species of Desmodium that has not yet been identified with certainty is a promising legume, as are centro (*Centrosema pubescens*) and creeping indigo (*Indigofera endacaphylla*). Plate 6.

Plate 6.—A creeping indigo (" Indigofera endecaphylla ") guinea (" Panicum maximum ") pasture at Sigatoka.

3. The most promising pasture to date has been a mixture of guinea and centro. A mixture of guinea and creeping indigo is also promising but unfortunately creeping indigo may be toxic.

4. A ley can be established under a nurse crop and Kavirondo sorghum (*Sorghum verticiflorum var. Kenya*) is apparently a good nurse crop for Nadi blue grass.

5. The proper management of leys is of vital importance and desirable management practices are (*a*) a thorough preparation of the seed bed, (*b*) sowing at the correct time : that is usually at the beginning of the wet season, (*c*) fertilising with nitrogen, (*d*) strip grazing or utilising small paddocks for rotational grazing, (*e*) mowing during periods of lush growth, (*f*) harrowing certain types of pasture in the period of lush growth and (*g*) spreading dung with a light harrow after grazing.

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III. PASTURE GRASSES AND LEGUMES SUITABLE FOR PERMANENT HILL GRAZING

BY W. J. A. PAYNE, W. I. LAING AND N. S. MILES

The rough hill grazings at Sigatoka comprise approximately 500 acres of which 250 acres are gentle and the remainder steep or very steep slopes. The hill soils are shallow being six to eighteen inches deep and generally overlying rock. They are of two types, Kabesi clay a grey soil and Tuvu clay a red soil, both types being typical of the soils of large areas of the hill grazings in the dry zone of Viti Levu.

Climatic conditions are similar on the hills to those in the valley with the exception that air temperatures are usually 1-3° F. cooler.

It is probable that in the distant past the hills were covered with forest but in historical times the natural vegetational climax has consisted of the reed known as "gasau" (*Miscanthus japonicus*) interspersed with a few other species the most important being a climbing legume known as "Wa yaka" (*Pueraria hirsuta*). Unrestricted burning and intermittent grazing by stray cattle has in recent times destroyed the reed and almost replaced it by an unstable mixed population of grasses, legumes, and weeds. The most important of the grasses are "gi" (*Imperata cylindrica*), native blue grass (*Amphilophis glabra*), seed grass (*Chrysopogon aciculatus*), citronella grass (*Cymbopogon nardus*), Natal red top (*Tricholæna rosea*) and wire grass (*Sporobolus diander*). Important legumes are *Desmodium heterophyllum, Alysicarpus vaginalis, Desmodium trifolium* and *Atylosia scarabeoides,* and common weeds are guava (*Psidium guayava*), tobacco weed (*Elephantopus mollis*), blue rat tail (*Stachytarpheta urticæfolia*) and bracken fern (*Gleichenia linearis*). It is interesting to note that the legume *Desmodium heterophyllum* is more common on the red than on the grey soils.

Until 1949 little attention was paid to the rough hill grazings and all the observations recorded in this paper have been made since that date.

RESULTS.

No replicated controlled experiments have been carried out on the hill grazings but some observational trials have been laid down and some experience has been gained in the practical problem of clearing and reseeding or oversowing some of the lower slopes.

On 11th January, 1950, one of the more fertile areas of the hill on field 29 was planted with twenty-three of what appeared at that time to be some of the more desirable grasses, in order to obtain information as to how tney would establish themselves in competition with the local flora. The area was not weeded. Six months later sixteen species were still alive (Table 1) and good vigorous growth was shown by guinea, Nadi blue, Batiki blue and mission grass. In April, 1953, guinea, Nadi blue and Batiki blue were growing vigorously and obviously spreading at the expense of the other species. Woolly finger had also survived but did not appear to be as competitive as the other three species.

A number of grasses and legumes including several temperate zone species were also planted out on a hill-top site that was fenced against stray cattle in April, 1950. By April, 1951, the only surviving species were Spanish clover, Kaimi clover, creeping indigo, and Vasey grass (Table 2) but guinea grass had invaded the area and established itself, and by April, 1953, after the fence had been taken down and the area had been grazed for twelve months by wandering cattle the only surviving species were creeping indigo and Vasey grass.

During the period 1949-51 two areas of the steep slopes were enclosed. Fields numbered 22, 23, 23 (*a*) 24, 25 26 and 27 were enclosed as calf paddocks, and in the south section of the farm all the hill slopes were enclosed for goats, cattle and horses. The following observations on the effect of enclosure and clearing have been made.

TABLE 1.

COMPETITION PLOTS IN FIELD No. 29.

Observations 10/10/50.	Established 11/1/50.
Para (*Brachiaria mutica*)	Disappeared.
Thurston (*Brachiaria distachya*)	Disappeared.
Little para (*Urachloa spp.*)	Disappeared.
Queensland guinea (*P. maximum var. coloratum*)	Living but not thriving.
Guinea (*Panicum maximum*)	Vigorous.
Dallis (*Paspalum dilatatum*)	Disappeared.
Sour grass (*Paspalum conjugatum*)	Growing well.
Russel river (*Paspalum galmarra*)	Growing well.
Woolly finger (*Digitaria melangiana*)	Growing well.
Nadi blue grass (*Dichanthium caricosum*)	Vigorous.
Barbados sour grass (*Andropogon pertusus*)	Growing well.
Caboni grass (*Amphilophis glabra*)	Living but not thriving.
Jaragua grass (*Hyparrenhia rufa*)	Disappeared.
Many Headed blue grass (*Dichanthium annulatum*)	Living but not thriving.
Batiki blue grass (*Ischæmum aristatum*)	Vigorous.
Molasses grass (*Melinis minutæflora*)	Growing well.
Natal red top (*Trichloïæna rosea*)	Living but not thriving.
Mission grass (*Pennisetum polystachyum*)	Vigorous.
Rhodes grass (*Chloris gayana*)	Vigorous.
Couch grass (*Cynodon dactylon*)	Vigorous.
Crows-foot (*Eleusine indica*)	Vigorous.
Kangaroo grass (*Themeda quadrivalvis*)	Vigorous.
Jungle rice (*Echinochloa colona*)	Vigorous.

Plate 7.—A newly established guinea ("Panicum maximum") pasture with guava scrub over the fence on the hills at Sigatoka.

Field No. 22 was cleared from dense guava in 1949 and at that time was almost bare except for some bracken and a small patch of guinea. Since 1949 the field has been shut up during December, January and February of each year when the guinea has been allowed to seed itself and the whole area has been lightly grazed and periodicaly mown with an Allen Scythe. Five hundredweight of basic slag per acre was applied in 1952. The guava has disappeared and the dominant species now are guinea, tobacco weed, and *Desmodium heterophyllum*. Plate 7.

TABLE 2.

COMPETITION PLOTS ON THE HILL TOP.

	Established 13/4/50. Observations. 10/4/51	13/4/53.
Spanish clover (*Desmodium uncinatum*)	Vigorous	Disappeared.
Kaimi clover (*Desmodium canum*)	Growing well	Disappeared.
Creeping indigo (*Indigofera endacaphylla*)	Vigorous	Vigorous.
Lucerne (1) (*Medicago sativa var ?*)	Disappeared	Vigorous.
Lucerne (2) (*Medicago sativa var ?*)	Disappeared	Vigorous.
Red clover (*Trifolium repens var ?*)	Disappeared	Vigorous.
White clover (1) (*Trifolium repens var ?*)	Disappeared	Vigorous.
White clover (2) (*Trifolium repens var ?*)	Disappeared	Vigorous.
Lespedeza (*Lespedeza spp.*)	Disappeared	Vigorous.
Vasey grass (*Paspalum urvillei*)	Vigorous	Growing well.
Ryegrass (*Lolium perenne*)	Disappeared	Growing well.
Cockfoot (*Dacytylis glomerata*)	Disappeared	Growing well.

Field No. 23 (*Triangle*) was cleared from dense guava in late 1949. It was sown with calapo and a little centro, and has been lightly grazed and mown continuously with an Allen Scythe. Five hundredweight of basic slag per acre was applied in 1952. The dominant species until the end of 1952 was *Desmodium heterophyllum* with some calapo, centro, guinea, tobacco weed and seed grass. The field was shut up during the 1952-53 wet season. At the end of 1953 the dominant species was guinea.

Field No. 23 cleared 1952-53. Some centro had been sown at an unknown date previous to this operation. The dominant species were guava and tobacco weed that had regrown after a previous clearing but guinea is already invading this field.

Field No. 24 was cleared in 1950 but Nadi blue grass was already present having been sown on an unknown date prior to 1949 when this field was used as a series of fowl runs. There is now a good cover of Nadi blue grass with some tobacco weed in it. There are many shade trees in the field and it has been noted that unlike guinea Nadi blue grass does not grow well under shade trees.

Field No. 25 was cleared in 1950 and sown with Nadi blue grass which soon dominated all the weed species on the hill, so that by 1952 there was a complete cover. In 1952 basic slag at the rate of five hundredweight per acre was applied and this has resulted in a most vigorous growth of *Desmodium heterophyllum, Desmodium triflorum, Alisicarpus vaginalis* and sensitive (*Mimosa pudica*) in competition with the Nadi blue grass. It is very noticeable that the Nadi blue is more leafy and is making more vigorous growth in those sections where it is mixed with legume.

Field No. 26 was cleared in 1952 and sown with Nadi blue grass. At present there is a mixture of young guava regrowth, tobacco weed, Nadi blue and guinea.

Field No. 27 was cleared in 1952 and sown with guinea and Nadi blue grass. At present there is approximately the same mixture as on field No. 26.

Field Nos. 28, 29 and 31 were badly overgrazed in the past. They have been rested during the last two years and the light guava was cleared in 1953. Guinea appears to be invading and spreading on this hill, but it is still full of guava regrowth and tobacco weed.

Field Nos. 34 (*a*) and 34 (*b*), 35 and 36 had been virtually unstocked for some years until 1951. The dominant species was "gasau" with guinea and some guava. The reed was burnt off during the 1951-52 season and the guinea has spread rapidly. Unfortunately a great deal of tobacco weed has also established itself. Poor fencing in this part of the farm has prevented proper rotational grazing and the spread of guinea has been arrested by set stocking.

An observational trial on the use of phosphate, lime, and trace elements on the hill was laid down in August, 1949. Superphosphate at the rate of four hundredweight per acre, and coral sand at the rate of ten hundredweight per acre were spread in strips running up and down the slope. Different trace element mixtures of molybdenum, zinc, copper, and cobalt, were sown across the slope. Some details are given of the percentage increase in cover five months after application in Table 3. Observations on April 13th, 1953, showed that there was a striking growth of legume on the area on

which the phosphate was sown. This confirms evidence from the calf paddocks where the application of phosphate led to a striking increase in legume cover. In view of the apparent effect of molybdenum and copper, soil samples were sent to the Waite Institute in Adelaide, South Australia for spectrographic analysis. These analyses did not reveal any major trace element deficiencies.

TABLE 3.
EFFECT OF FERTILISER ON HILL GRAZINGS.

Treatment.	% increase in cover August-November, 1949.
Control	165
P	201
Ca P	250
Mo	183
Mo Cu	247
Ca P Mo Cu	446

Small areas of the hill have been burnt off during this period either by accident or design. In every case it has been noted that if a few plants of guinea are present in the original grazings this species will grow again very rapidly on the burn, and that young guinea plants grow much more rapidly than any other species.

DISCUSSION.

Evidence from the observational trials and from the clearing of small areas of the rough hill grazings suggest that the following species may be useful on hill grazings. Guinea, Nadi blue, woolly finger, mission grass, Vasey grass, centro, *Desmodium heterophyllum*, *Alisicarpus vaginalis*, and creeping indigo. Plate 8.

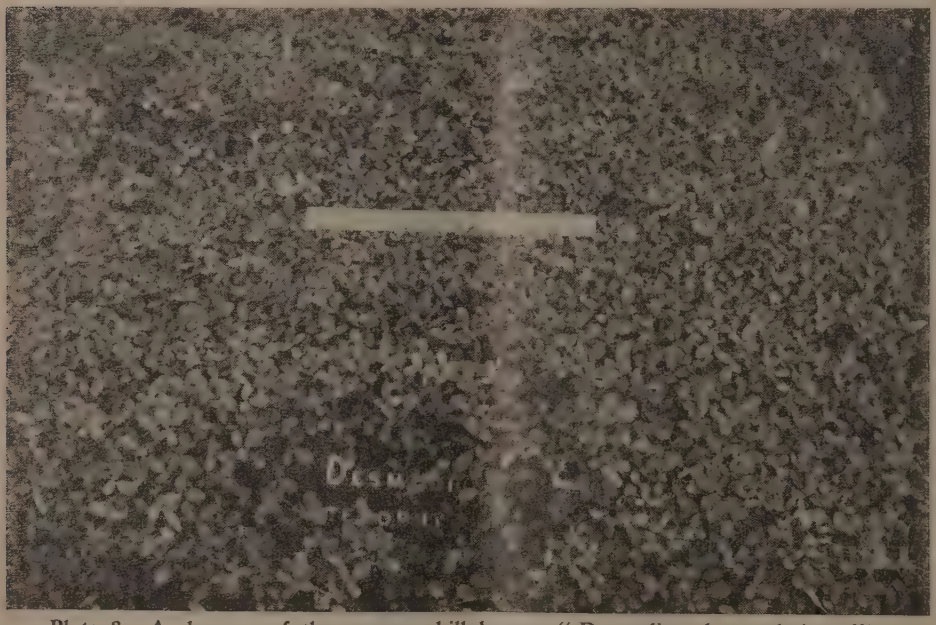

Plate 8.—A close up of the common hill legume "Desmodium heterophyllum").

Guinea grass is quite an outstanding species on the hills. If an area is enclosed it will invade it and rapidly establish itself, and if it is not grazed it will push out all other grasses and even weeds such as guava and tobacco weed. If an area is burnt in which some guinea already grows it will establish itself on the burn much more quickly than any other species. The combination of these two characteristics ensure that if an area is enclosed on which some guinea is already established and the area is then burnt at the end of the dry season immediately before the time that guinea exhibits maximum growth, the guinea will spread rapidly and within one or two years establish a complete cover. The factor that stops guinea spreading to-day in the Sigatoka Valley rough grazings is wandering cattle. They relish the young guinea as it

is so palatable and they pull it out before it is properly established this being easy to do as guinea is not a creeping plant but has a crown that is easily pulled out or destroyed when the plant is young. Guinea seeds profusely but the ripening of the seed is very uneven and seed samples are usually of low viability, a phenomena that has been noted overseas (Motta (1953)). This does not matter if it is allowed to seed itself from isolated clumps but it makes it difficult to establish in the first place from seed. It is most quickly established on a new area by planting divided crowns. They can be widely spaced along the ridge of a hill so that any seed that is subsequently produced will fall down the slopes and spread the grass more rapidly. It flowers and seeds from December to March in the Sigatoka area. This is a great advantage as fields can be shut up to allow the guniea to seed during periods of flush growth ; that is at the most convenient time for the farmer. Guinea grows luxuriantly during the wet season on a wide range of different soils in the dry zone, but it will also grow well in the wet zone if the land is well drained. It withstands drought better than most other high yielding tropical grasses and during the drought of 1953 was one of the few species producing any feed at all in the dry zone. It stands intensive stocking but not set stocking and recovers very quickly after grazing and with proper grazing management it will produce a dense growth of leafy fodder. Experience at Sigatoka suggests that it should be kept down to a height of six to eight inches. If it is not grazed frequently enough it will get out of control and grow tall and stemmy. Nothing is yet known as to the carrying capacity of the guinea pastures on the hills at Sigatoka but overseas Motta (1953) states that the carrying capacity of guinea pastures is five to ten cattle per ten acres. A further advantage of guinea grass is that it grows just as well under light tree shade as on the open hill so that it can grow right up to the bole of any interplanted shade trees. A combination of guinea and leguminous shade trees make excellent hill grazings. Guinea has been shown to mix well with centro on the alluvial flats at Sigatoka (Payne *et al.* (1955)) and there is no doubt that it would also do so on the hill grazings. In Queensland guinea has also been found to mix well with centro, and it is advised that the seed rate should be six pounds of guinea and two pounds of centro per acre and that the mixture should not be grazed until after the first seeding of the guinea (Barrau (1953)).

Nadi blue grass establishes itself from seed on the hills at Sigatoka, seeds profusely and forms a dense cover. It is palatable and stands very heavy stocking. It responds to applications of basic slag and when this is applied the hill legumes *Desmodium heterophyllum, Desmodium triflorum, Atylosia scarabeoides* and *Alisicarpus vaginalis* grow extremely well and form a mixture with the Nadi blue grass. Its dry season production is, however, very poor and in the 1953 drought it almost disappeared on the hills at Sigatoka although it made a good recovery during the 1953-54 wet season. It is very aggressive and once established it is probably difficult to eradicate. As the limiting factor on the stocking rate of any hill grazing is the stocking rate in the dry season Nadi blue grass pastures on the hill could only carry a small number of animals as compared with guinea grass pastures.

Mission grass grows well on the hill in the dry zone but it rapidly becomes stemmy and is then quite useless as a stock feed. It is possible that with adequate fencing the grazing of it could be controlled and it could be kept palatable, but this is conjecture as no trials have been laid down to test this hypothesis. As it has the same habit of growth as guinea grass and as guinea grass appears superior in every way there seems little purpose in using this grass.

Vasey grass has not been used on any scale and little is known as to its establishment and management.

Contrary to the usual concensus of opinion, there is no lack of legumes in the rough hill grazings. Four useful species are widely spread *Desmodium heterophyllum, Desmodium trifolium, Alisicarpus vaginalis* and *Atylosia scarabeoides* and several other quite useful species are also to be found. All these are palatable and are eaten by cattle even though their total production is small and does not contribute greatly to the feeding of cattle on the hills. Observational

trials have shown however, that their growth is vastly improved by the application of phosphatic fertilisers. It is also possible that small quantities of the trace elements copper and molybdenum may assist legume growth.

Little is yet known of the economics of clearing the hills, establishing desirable grasses and legumes and applying fertilisers to improve the sward but it has been shown clearly that there is nothing intrinsically difficult in establishing a good pasture on the hills as guinea and Nadi blue grass pastures have already been successfully established.

SUMMARY.

1. Guinea grass (*Panicum maximum*) is an outstanding grass for use in the establishment of pastures on the hills in the dry zone.

2. Nadi blue grass (*Dichanthium caricosum*) produces a good sward from seed, but it produces little or no feed at the most critical time of the year, that is in the dry months.

3. There are at least four important legumes already growing on the hills, *Desmodium heterophyllum, Desmodium trifolium, Alisicarpus vaginalis* and *Atylosia scarabeoides* and the application of phosphates will increase the contribution of these legumes to the hill grazings.

Plate 9.—A close up of the common hill legume " Atylosia scarabeoides.

4. There is every reason to believe that the legume centro (*Centrosema pubescens*) will mix well with guinea grass on the hill just as it mixes with guinea grass in a ley and it is likely that a guinea-centro mixture can be established on the hill grazings.

ACKNOWLEDGMENTS.

The authors wish to thank the Director of Agriculture for providing facilities for these trials, and the Director of the Waite Institute, Adelaide, South Australia for carrying out spectrographic analyses of the hill soils.

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TOPDRESSING PASTURES I

A PRELIMINARY REPORT ON RESULTS OF THREE OBSERVATIONAL TRIALS WITH FERTILIZER ON PASTURE LAND IN THE TAILEVU DISTRICT

BY A. R. BROWNING

Observational trials using fertilizers on pastures in Tailevu were commenced in July, 1954. These trials were started on a small scale as preliminary investigations into the possibility of improving production of para grass during the winter months when growth slows down and shortage of suitable feed reduces milk yields on most farms. The trials were all laid down on the richer, river-flat pastures which consistently outyield hill pastures, and it is a matter of some interest that the responses reported below should be obtained on the best soils of the district, and on what is without doubt the best known pasture grass for the wet zone.

Farm 1—

Two areas were topdressed on this farm. One field received 2 cwts. of ammonium sulphate per acre, the other 1 cwt ammonium sulphate plus 2 cwts. of superphosphate. Fertilizers were applied immediately after the field had been grazed in the normal rotation. Responses were slow. It was six to eight weeks before any changes were visible. Towards the end of August, however, marked differences in colour and growth were apparent. The topdressed areas were by this time much darker in colour and were quite definitely making more growth than adjacent, otherwise comparable fields. These fields were normally grazed every twenty-one days in the rotation. For four grazings after response occurred, this time was cut to seventeen days on the topdressed areas. The owner of the farm was of the opinion that growth in the seventeen day periods was equal to that in the twenty-one day periods on the adjacent, untopdressed fields. By the end of December improvement due to fertilizers was no longer visible. It was originally proposed that the fertilizers should be split, half to be applied in July, the balance in September. In the event, it was all put on in July. In view of the result on Farm 2, it seems likely that increased growth of greener grass would have been maintained longer than was the case, had fertilizers been applied in two lots. Responses were much the same on the two fertilized fields, no visible difference being observed at any stage.

Farm 2—

On this farm, ammonium sulphate alone was used. Two dressings of $\frac{3}{4}$ cwt per acre were applied, one in July, the second in September. Both topdressed and control areas were grazed and then mowed, immediately before topdressing. Response on this farm was rapid. Within ten days of the first application marked differences in colour and growth were visible. The effects of the second application were very obvious on the fourth day after application, and in February of 1955, eight months after the initial application and six months after the second, the owner of this farm was confident that the topdressed areas were still producing more grass than adjacent and otherwise comparable fields. Normally on this farm calves are rotated ahead of the milking herd. During the period when responses to fertilizers were evident, however, calves were kept in topdressed paddocks continually and the milking herd put through the area once only. It is not possible, therefore, to say as with Farm 1, that over a period the rotation time was cut by twenty per cent (or, that production of grass rose by twenty per cent), but the following observations indicate that responses were considerable and of the same magnitude as on Farm 1. On Farm 2 the topdressed area was reckoned to be ready to feed off twelve days after the first application. Within ten days of applying ammonium sulphate, para grass was as much as 10 or 12 inches taller on topdressed parts than on the otherwise comparable untopdressed ones, and was a

much darker green. Further, the leaf-stalk ratio, was markedly increased. That is, considerably more leaf was grown relative to the amount of stalk on topdressed than on untopdressed areas. Also, stalk was more palatable as was clearly visible after grazing when the average level of grass remaining in the topdressed fields was eight to ten inches lower than in untopdressed ones. The number of clumps of brown stalk left standing after grazing, to a height of thirty to thirty-six inches in the untopdressed areas stood out in contrast to the few, lower clumps in the topdressed parts. From the farmer's observations it is clear that not only did the topdressed areas produce leaf rather than stalk, but stalk that was grown was more palatable to stock.

Farm 3—

Early results on this farm were also very encouraging. Within ten days of topdressing with ¾ cwt ammonium sulphate and 1¼ cwt of superphosphate per acre, growth was much higher than on adjacent parts and the colour was much darker. For one reason and another, however, this farmer did not follow up, the area was not grazed when ready, and little was learned on this property except that the initial response was very much the same as on Farm 2.

It is hoped that analyses of the protein and perhaps phosphorus, contents of pasture samples can be carried out during the course of further trials this year. It may be expected with confidence that these two important factors of quality in pastures will be enhanced by topdressing, apart from the extra bulk of grass being grown.

The first stage of establishing a dairy industry in Tailevu is completed. Land has been cleared and subdivided, herds have been built up, and, to a large extent, by hard work alone, the dairy farmer has established himself economically. The second stage of development has now commenced for many of the farms.

Initially the problem was to clear the land, and to grass, fence and stock. Now the problem is, for an increasing number of farmers, to increase *production per acre*, on existing grasslands. There are many facets to the problem. For instance, much remains to be done about weed control. Animals prefer nutritious grass and legumes to weeds. It is probably no exaggeration to say that some pastures exist which are up to fifty per cent weeds. If these weeds were eradicated and grass grown in their place, many farmers could increase their stocking rate immediately. Others would perhaps not increase their stocking rate, but would certainly increase production from their present herds. More attention might profitably be paid to better rotation of stock through pastures on many farms. More rigorous culling, in some cases any culling, would help measurably to get more return from pastures on many farms. Allowing for all these things being done, however, and they are being done to a greater or lesser extent throughout the district, there comes a time when they are not enough in themselves. The time will come for most of the farmers, as it has already come for some, when the problem is no longer weeds, rotations, further subdivision, culling and the like. The basic matter of the soil fertility remains.

No amount of good farming will replace nutrients lost from any farm when crops and animal products are sold off the land, nor will it replace the much greater amounts washed from the soil in hot humid climates, unless fertilizers are used. Better, higher producing animals can only produce well on good pastures, and good pastures can only be established and maintained on fertile soils. Production on some Tailevu farms is now being held up by the inherent low fertility of the soils and further increases in production on these farms, and as time goes on, on most other farms in the district, will depend on the use of fertilizers. There is no doubt that production can be increased by the use of fertilizers and very little doubt that it will pay. A great deal of work must be carried out to establish just what fertilizers are needed, the best times and rates of application, the best grasses to grow on topdressed land, possible alterations in management to get the maximum return from increased fertility, and so on, but results so far with pastures and other crops leave no doubt about the possibilities of increasing production with fertilizers.

Although fertilizer can be expected to increase production measurably on some farms now, it is not a "panacea". The use of fertilizer is only one part of good farming. Fertilizing weedy pastures will often do little else but increase the growth of weeds and so have, in balance, an undesirable effect. Also, the most economic results will only accrue from the use of fertilizer if farms are closely subdivided, so that intensive rotational grazing is possible. The correct use of fertilizers will promote continuous growth of grass with higher protein content, and will help quick "get away" after grazing. Proper utilization of young, rapidly growing, high quality grass can only be achieved if pastures are subdivided sufficiently to ensure that grass is eaten right down quickly, at the right time. Para grass paddocks should be, ideally, not greater than two acres and hill paddocks, when used for dairy production, not more than five acres. Fertilizers will only produce their maximum and most profitable effects on weed-free, properly subdivided pastures.

There is plenty of scope for marketing increased production from grassland farming in Fiji, as the following figures for 1954 show.

	Produced Locally.	Imported.	Total Consumed.	Value of Local Production as % of Consumption.
Butterfat, Ghee and Substitute	£150,000 (607,000 lb)	£137,000 (698,000 lb)	£287,000 (1,305,000 lb)	52
Milk, Whole, produced for sale locally ..	£100,000 (5,400,000 lb)			..
Milk, condensed, dried and evaporated	....	£121,000 (1,182,000 lb)	£221,000 (6,582,000 lb)	45
Beef, Fresh	£115,000 (4,116,000 lb)			..
Beef, fresh and preserved	....	£165,000 (1,138 000 lb)	£280,000 (5,254,000 lb)	41
Total Value of Grassland Products ..	£365,000	£423,000	£788,000	46

What portion of the £423,000 imported butter, milk, ghee and meat could be satisfied by locally produced goods is difficult to say. There will undoubtedly always be a market in Fiji for some tinned milk and meat. However, it would seem likely that with an increasing population and increasing standards of living locally, and the possibilities of export to neighbouring Pacific territories, a market could be found for at least £750,000 of produce from Fiji's grasslands. If this potentiality is to be realized, more land will have to be brought into pasture, but equally, and perhaps more important, all Fiji's grassland, both present and future, will have to be used more efficiently. *Returns per acre* will have to be increased. The three small trials reported here indicate that there are possibilities of increasing the efficiency of producing from our grasslands by using fertilizers.

NOTE.—It should be mentioned that the trials outlined above were carried out by the three farmers at their own expense, and that they are sufficiently impressed with results so far to carry on with the investigations this year.

VERMIN CONTROL . . .

A MONGOOSE TRAP

BY R. MERCER*

The present article gives a description and plan of a noose trap for use against mongoose. (Figure 1). The trap is not capable of catching dogs, or cats by mischance

Materials required—

1 stick of springy wood, 7 feet long, about 1 inch diameter in the middle ; wild yaqona or lemon.

2 stakes with hooks like grass cutting hooks, 1 foot—15 inches long, ½ inch diameter.

Sufficient reeds 1 foot long to make an enclosure 1 foot long and 6-8 inches wide ; or piece of tin.

2 reeds 8 inches long for crossbars at entrance.

1 reed 5 inches long for trigger bar.

6-7 feet of fishing line ; about 2 feet for the trigger and 4 feet to 4 feet 6 inches for noose.

Piece of meat for bait, staked to the ground between middle and far end of enclosure.

Setting the trap—

Tie 2 lengths of fishing line to the tip of the 7 feet stake, one about 2 feet long the other about 4 feet, with a running noose. Plant this stake firmly in the ground.

Bend the stake over till the tip is 2 feet from the ground and set the two hooked stakes deep into the ground directly beneath the tip of the stake, and 7 inches apart, the hooks projecting downwards on the outside and 6-8 inches above ground.

Build the enclosure, rectangular or U shape, 1 foot high from the 2 hooked stakes back towards the spring stick.

Tie a reed or pencil-thick twig 5 inches long by one end to the shorter of the two lines attached to the spring stake. This short twig holds the two cross reeds in position, one under the hooks of the two stakes at the entrance, and the lower one about ½ to 1 inch above ground level.

This trigger bar is set vertically, well off-centre of the entrance so that the mongoose will pass through the larger entrance covered by the noose. The bottom of the noose, depending from the bent spring, just touches the ground and encircles the rectangular entrance.

Before the noose is adjusted the short reed attached to the shorter line is passed inside the top bar, to which it is hooked by the short projection above the point of attachment of the twine, while the other end presses against the outside of the bottom bar, holding it firmly in place. The trigger stick should not project far beyond the bottom bar, or it may catch on the ground when released, which is done by the mongoose depressing the bottom bar when entering the enclosure.

When the bottom bar is pressed down, the trigger stick flies out and the spring snatches the noose up with the mongoose in it.

If the noose does not lie nicely over the entrance it may be held in place with blobs of clay on the stakes at each side of the entrance.

These hooked stakes must be driven deeply in, otherwise after rain the spring will pull them out of the ground.

This type of trap is very effective in areas thickly infested with the mongoose, but in areas where there are not so many, e.g. in well weeded places, or in town areas, I would suggest the use of the box or wire trap. This trap can stay set for many weeks or months if it is not upset by dogs, whereas the other loses its power if not sprung within a day or so of setting, and also the box trap can be shifted about easily.

* Article contributed on request.—Ed.

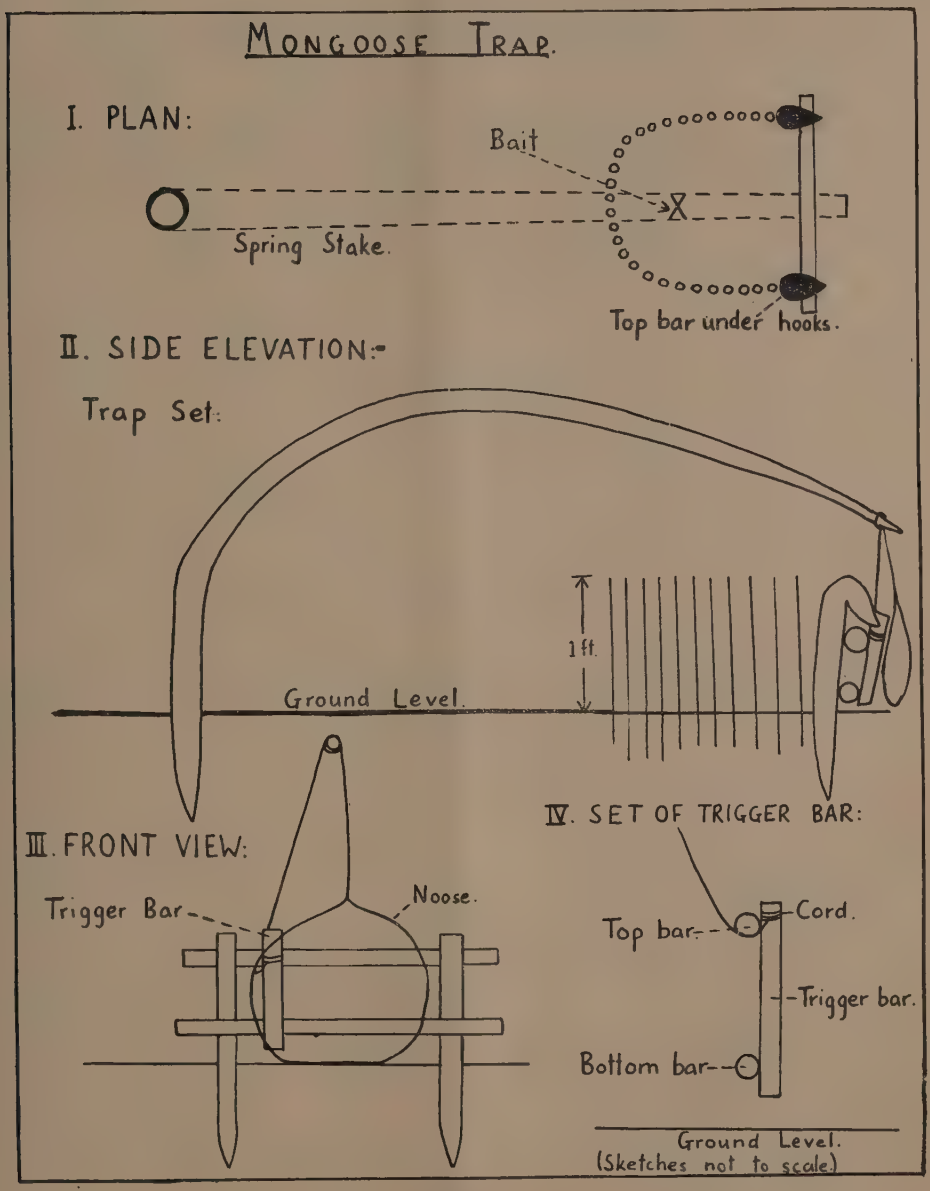
MONGOOSE TRAP.
I. PLAN:
Bait
Spring Stake.
Top bar under hooks.
II. SIDE ELEVATION:-
Trap Set:
1 ft.
Ground Level.
III. FRONT VIEW:
Trigger Bar
Noose.
IV. SET OF TRIGGER BAR:
Top bar
Cord.
Trigger bar.
Bottom bar
Ground Level.
(Sketches not to scale)

Figure 1.

MARKETING NOTES . . .

EXPORT OF PRINCIPAL CROPS 1954

(Expressed in f.o.b. Values)

Commodity	Quantity	United Kingdom	Australia	New Zealand	Canada	Western Samoa	Tonga	U.S.A.	Other Countries and Ships Stores	Total
		£F	£F	£F	£F	£F	£F	£F	£ F	£F
Bananas . . . . . cases	344,305	....	2	319,223	....	....	....	....	44	319,269
Copra . . . . . tons	4,223	324,424	....	....	....	....	....	....	....	324,424
Coconut Oil . . . . . tons	17,027	2,153,343	....	....	....	....	....	....	....	2,153,343
Coconut Meal . . . . . tons	7,076	12,279	....	52,843	13,248	....	2	46,122	1,405	125,899
Coconuts Fresh . . . . . No.	638	....	....	6	....	....	....	....	2	8
Sugar Raw . . . . . tons	136,927	1,595,763	....	1,622,715	2,176,661	60,801	17,836	....	20,518	5,494,294
Molasses . . . . . tons	41,209	....	46,360	....	....	....	....	....	....	46,360
Rice Bran . . . . . tons	773	....	....	5,805	....	1	....	....	....	5,806
Pineapple Juice . . . . tons	232	2,058	2,815	1,353	2,058	164	13	5	9,261	17,727
Pineapple Canned . . . . tons	443	9,117	3,687	40,117	7,285	223	11	....	5,042	65,482
Pineapples Fresh . . . . cases	130	....	....	122	....	....	....	....	16	138
Peanuts . . . . . tons	34	....	....	765	....	....	....	....	3,180	3,945
Ginger Green . . . . . tons	26	....	....	997	....	....	2	....	....	999
Citrus Fruit . . . . . cases	11	....	....	....	....	....	....	....	10	10
Melons . . . . . No.	17,132	....	....	3,205	....	....	....	....	40	3,245
Vegetables, Miscellaneous . . tons	157	....	....	2,238	....	....	....	....	3,324	5,562
Fruit, Miscellaneous . . . . tons	43	....	....	282	....	....	....	....	1,839	2,121
Cow Hides . . . . . No.	10,123	....	16,979	1,373	....	....	....	....	....	18,352
Totals	....	4,096,984	69,843	2,051,044	2,199,252	61,189	17,864	46,127	44,681	8,586,984

SOME AGRICULTURAL AND PASTORAL PRODUCTS IMPORTED DURING 1954

(Expressed in f.o.b. Values)

Commodity	Quantity	United Kingdom	Australia	New Zealand	Canada	India Burma and Malaya	Other Countries	Total
		£F	£F	£F	£F	£F	£F	£F
Potatoes . . . . . tons	2,502	....	11,814	79,926	....	....	....	91,740
Garlic . . . . . tons	133	....	10,159	2,610	....	1,417	4,957	19,143
Onions . . . . . tons	1,315	....	20,167	54,944	....	....	48	75,159
Spices . . . . . lb	373,128	259	5,756	141	....	3,963	16,590	26,709
Rice . . . . . tons	663	....	44,788	18	....	....	7,640	52,446
Pulses . . . . . tons	1,123	....	30,669	6,690	....	35,302	427	73,088
Coffee . . . . . tons	18	3,804	7,766	953	....	2,138	429	15,090
Ghee and Substitutes . . lb	490,815	....	3,476	106,709	....	....	....	110,185
Butter and Substitutes . . lb	207,202	....	9,870	16,774	....	....	....	26,644
Edible Oils . . . . . gal.	98,234	797	25	44	....	75,150	9,371	85,387
Eggs . . . . . doz.	30,293	....	2,669	5,246	....	....	....	7,915
Poultry and Game . . . . lb	35,860	....	2,092	5,359	....	....	....	7,451
Beef Fresh, Canned, Dried and Salted . . . . . lb	1,138,027	....	475	164,751	....	....	....	165,226
Fish Fresh, Canned, Dried and Salted . . . . . lb	1,761,744	49,757	1,943	5,658	20,280	350	79,631	157,619
Milk, Condensed, Dried and Evaporated . . . . . lb	1,182,012	....	90,705	31,390	....	....	32	122,127
Totals	....	54,617	242,374	481,213	20,280	118,320	119,125	1,035,929

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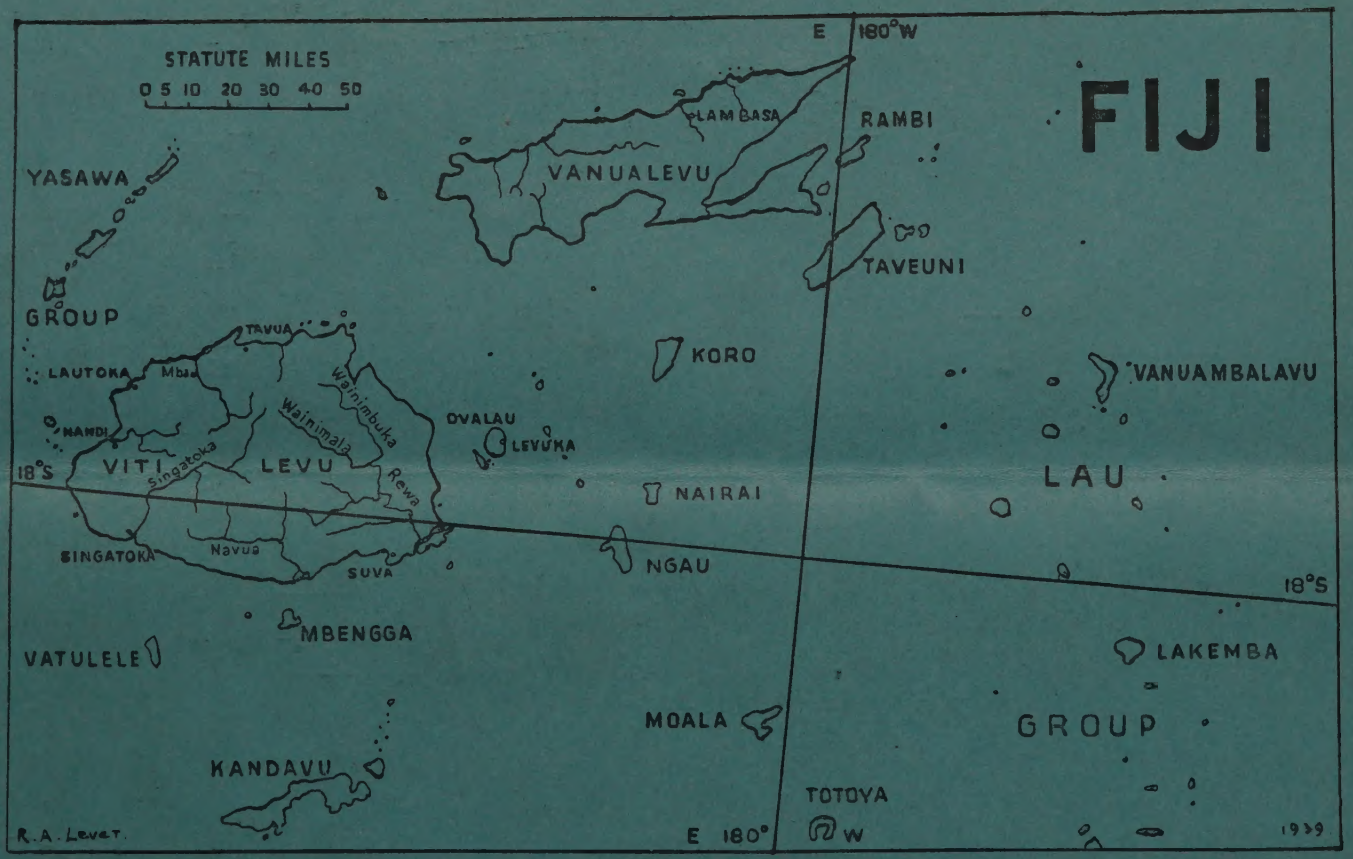

So as to include Kadavu and Totoya within the framework available the map has been rotated some 6° to the east.